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COLLECTION AND PREPARATION OF MATERIAL FOR CLASSES IN ELEMENTARY ZOÖLOGY.

BERTRAM G. SMITH.

DURING the past year the writer has frequently received inquiries concerning methods of collecting and preparing zoölogical material for class use. The purpose of the present article is to give some of the methods used in the Department of Zoölogy of the University of Michigan in supplying a class of over a hundred students with laboratory material for a first course in elementary invertebrate zoölogy. A few organisms are included that are not ordinarily studied in a beginners' course, as some of them may be found useful for demonstrations, or for supplementary work. On the other hand, no attempt is made to make the list comprise all the forms adapted to a first year's course; for many of these, directions for collecting would be superfluous.

1. *Amœba.*[1]— Collect the water plant Ceratophyllum, which will be found growing in the quiet water of ponds and rivers, in the same habitats with water lilies, Elodea, etc. Gather the Ceratophyllum in considerable quantities, packing it in pails

[1] H. S. Jennings. "Methods of Cultivating Amœba and Other Protozoa for Class Use." *Journ. of Applied Micr.*, vol. 6, no. 7, p. 2406.

with enough water to cover. It is best to get material from several localities. If Ceratophyllum cannot be found, Elodea and various other plants may be used, but the results are less satisfactory.

Bring the material to the laboratory and there set up cultures as follows. Use "bacteria dishes" — shallow circular glass dishes, about 9 inches in diameter and 3 inches deep. Pack the material in these *firmly*, crushing it down. This will prevent growth of the plant, and favor fermentation. Pack to within an inch of the top of the dish, and add just enough water to cover the material. Cover the dishes with glass plates and put them in various warm and well lighted places about the laboratory. Each culture should be labeled with the *place* where the material was obtained, and the *date* when the culture was set up. Later, as organisms appear which are to be studied, their *names* should be added to the labels. *Label the dishes, not the covers.* If water evaporates so as to expose the plant material, enough should be added from time to time to make good the loss.

The first cultures should be started about *three weeks* before the Amœbæ are needed. A half dozen cultures should be started at this time and several new ones added every two or three days thereafter, until the class is nearly through studying Amœba. The time required for the cultures to mature varies; a single culture may last but a few days, and not all are successful — hence the necessity for frequent collections and many cultures.

The first indication of Amœba is a brown or a white scum appearing on the surface of the water. This consists mainly of bacteria, and the Amœbæ come to the surface to feed on them. Take up a bit of the scum with forceps, mount in a drop of water taken from the surface with a pipette, tease out the scum thoroughly with needles, and examine with a microscope. Amœbæ, if present, will usually be found among or near the particles of scum. Also, remove a bit of the plant material and scrape the slime from it. This will often contain more Amœbæ than the scum at the surface of the water. The specimens are small at first, but in a few days they become larger.

While the Amœbæ usually disappear from such a culture in a short time, occasionally they persist for a week or more, growing larger. In some cultures they seem to encyst or disappear almost entirely, and later reappear in considerable numbers. Hence old cultures should be watched, and retained until they become overgrown with fungi and hence worthless.

The advantages of the Ceratophyllum method, as described and used by Jennings, are that it gives Amœbæ in abundance, at the time desired, with almost absolute certainty. But the Amœbæ obtained by this method are seldom large; their development is often interfered with and they usually give place to other organisms before attaining maturity. Moreover, the presence of an excessive amount of bacteria and other organisms often obscures the Amœbæ, and makes it difficult to find and study them. To overcome these difficulties, the writer, aided by a suggestion from Professor Reighard, devised a modification of the above method which has proved a valuable supplement to it.

As soon as Amœba appears in the Ceratophyllum cultures, skim off the brown scum with a spoon, and put it in small bacteria dishes about four inches in diameter and one and one half inches deep, with enough water to fill the dish about one inch deep. Add a little of the decaying vegetable material from near the surface of the Ceratophyllum cultures. This should be done several days before the Amœbæ are desired for use. Cover the dishes and keep them in a *warm* place, but not in direct sunlight. In a few days Amœbæ will be found in abundance in some of these cultures, in the scum at the surface or in the ooze and on the decaying plant material at the bottom of the dish. Some of the cultures prepared in this way by the writer gave results far better than were obtained from the ordinary Ceratophyllum cultures; the specimens were remarkably large, active, and numerous. The Amœbæ pass through stages of development and sometimes practically all of them in a given culture encyst at the same time. They may reappear later in an active stage. Later on, among other organisms may appear in these cultures Arcella, Chilomonas, Paramœcium, Vorticella, and occasionally some colonial Protozoa.

2. *Arcella and Difflugia* will often be found in ordinary Amœba cultures, or in cultures made with dead water-lily leaves. In rather fresh cultures, these Protozoa may be found creeping along the surface of the vegetation. Take up a mass of the Ceratophyllum between the fingers and bruise it briskly against a watch glass; add a *little* water to the residue that clings to the glass. It will usually contain Arcella and Difflugia.

3. *Chilomonas* may appear at almost any time in Amœba cultures; but it is best to put up cultures especially for Chilomonas and Infusoria. Use Ceratophyllum and partly decayed water-lily leaves, and pack in bacteria dishes as for Amœba, but use less plant material and more water. Cultures prepared in this way may mature in a very few days. Mount a drop of the water containing Chilomonas, together with a little of the slime or decaying vegetable material by means of which the specimens may be entangled.

4. *Euglena* will appear in some of the cultures put up for Amœba, usually after the disappearance of Amœba, four or five weeks from the date of starting the cultures, but occasionally it appears before Amœba. It makes a solid deep-green (not blue-green) mass at the edge of the dish, especially on the side towards the light. A thick, pale brown, felt-like and granular scum on the surface of the culture seems to be favorable to the presence of Euglena. Such a scum contains delicate fungi, diatoms, desmids, Arcella, etc.

Euglena usually appears in only a few dishes, but in abundance, and lasts several days. Euglena is often associated with Phacus, which somewhat resembles it, but the latter organism is skate-shaped, and does not exhibit euglenoid movements.

Keeping the cultures away from a strong light may prevent the formation of an excess of chlorophyll in Euglena.

5. *Paramœcium.*—Prepare cultures in the same manner as for Chilomonas. Decaying water-lily leaves are especially good. The cultures require but a few days to mature, and last a long time. Mount a drop of water containing Paramœcia, together with a little of the decaying vegetable material about which they may collect.

6. *Vorticella* is often found on decaying duckweed, Riccia, and Ceratophyllum. Place a large handful of the material in a bacteria dish nearly filled with water. Vorticella often appears in cultures prepared for other purposes.

7. *Carchesium* often occurs on water snails and crustaceans amongst duckweed and Riccia. Collect in the same manner as Vorticella.

8. *Volvox* has been found to occur most abundantly amongst duckweed and Riccia, in pools or small ponds that do not dry up. Collect this material by dipping it up together with a little of the water and place a small handful of the material, with some of the water, in each of many bacteria dishes and add enough tap water so that the dishes are nearly full. Place the dishes so that one side is strongly exposed to light. After a few hours, specimens of Volvox may be seen with the naked eye, or with a hand lens, at the water's edge on the lighted side of the dish. Remove them with a pipette to a small covered dish filled with clean water. Volvox kept in clear water and strong light seeks the bottom of the dish, and can readily be found and removed with a pipette when wanted. If left in the original dish, there may be present small crustaceans which will eat them; yet Volvox may sometimes be collected from these dishes for several days. Usually the material yields best after a day or two, and in three or four days becomes worthless. If obtained free from the animals that prey upon it, Volvox may be kept for several days or even longer.

Volvox is not always present in localities that seem favorable for it, and ponds that contain it in abundance are somewhat rare. In some situations it may be collected to advantage by sweeping a bolting-cloth net over water plants, or, better, using a "Birge net," which has a coarse net over the top for keeping out large forms and trash.

Volvox may be preserved in 4% formalin. Formalin specimens show flagella better than living ones. On account of the uncertainty of obtaining Volvox late in the fall, a supply of preserved specimens should be laid in early in the season.

In studying Volvox, mount the specimens in hollow slides or on ordinary slides with cover-glasses supported by fine glass rods or by bits of broken cover-glass.

9. *Pandorina* sometimes forms a green scum on the surface of the water amongst water lilies, or on the lily leaves.

10. *Hydra* occurs most abundantly on the following plants: duckweed, Riccia, Ceratophyllum, Elodea, watercresses. Two methods of collecting may be used. (a). Method best adapted to duckweed and Riccia: bring in the material with enough water to keep it moist. Fill a large number of bacteria dishes nearly full of clear water. Place in each dish a *small quantity* of the plant material — scarcely enough to cover the surface of the water on which it floats. Place each dish so that one side will be exposed to the light. A day or two later hydras will be found in the extended condition, clinging to the side of the dish, especially the lighted side, to rhizoids of plants, or to dead plants and sediment at the bottom. They may be removed from the sides of the dish with a pipette, or if clinging to plants, the latter may be removed with forceps. Place the hydras in a covered dish of clean water with a small amount of actively growing plant material. Here they will keep indefinitely and may readily be found when wanted. It is not safe to leave them in the original dishes, as there may be present crustaceans which will eat them, or an excess of vegetable matter may cause the water to become foul, which is unfavorable for Hydra. However, the dishes should be inspected daily, for sometimes the material will yield Hydra indefinitely.

(b). When Hydra is to be obtained from large plants like Ceratophyllum and Elodea, the best method is as follows: place a considerable quantity of the plant material in each of several large bacteria dishes and cover it with water. In a short time the water becomes foul through the decomposition of vegetable matter; the hydras then loosen their hold upon the vegetation and may be found floating at the surface of the water. They must be picked off at once with a pipette and removed to clean water.

Hydra will reproduce readily by budding if kept in a fairly warm room; but the optimum temperature is not very high. It is said that if Hydra is kept in the dark at a slightly lower temperature than usual for several days, this will favor the formation of spermaries and ovaries. Rarely, a mature fertilized egg in the winter condition may be found.

11. *Planarians* are found on the under side of stones in running water. They are usually abundant in a locality if found there at all. They may be removed from the stones by means of a thin wooden toothpick, and placed in a bottle of water for transportation.

12. *Earthworms.*— The *collection* of earthworms should be attended to as early in the fall as possible, as dry or cold weather may make it impossible to get them later. It is well to lay in a supply of preserved worms during the spring or summer. Specimens to be kept alive should perhaps not be collected until after the first of October, but it will be unsafe to wait much longer. Each student will need two or three preserved, and one or two living specimens.

The form used in the Zoölogical Laboratory of the University of Michigan is *Lumbricus herculeus* Savigny. The specimens range in length from about 6 to 11 inches, with an average of about 8 inches. They come out of their burrows on warm, rainy nights, usually lying extended with the posterior end of the body still in the entrance of the burrow. They are most abundant in old, rich gardens and lawns. Go out with a lantern and a pail after it has become quite dark; the harder it rains the better. By stepping lightly and not allowing the light to shine upon them too long, one may seize the worms with the hand. To catch them requires quickness and dexterity; but they must be pulled gently from the burrow.

When brought into the laboratory the worms that are to be preserved for dissection should be placed immediately in covered bacteria dishes (9 inches in diameter by 3 inches deep) between sheets of moist filter paper; the covers should be adjusted so as to admit a little air. Not more than twelve specimens should be placed in a dish, as they will soon die if large numbers of them are left together. The dishes should be kept in a cool place, avoiding direct sunlight. In the morning the paper should be changed, and injured or dead specimens removed; the operation should be repeated as often as is necessary. After a day or two the worms will have eaten enough moist filter paper to clean the alimentary canal of earth, and are ready for preservation.

Worms to be kept alive for a considerable length of time [1] may be placed, immediately after collection, between folds of moist muslin in bacteria dishes, with not more than a dozen specimens in a dish. Change or wash the cloth occasionally — at least every two weeks. The worms may be fed on leaves, etc., if desired. With proper care, they will keep in this way for months, and are always clean and ready for use at a moment's notice. The writer has found that the worms will keep quite as well if filter paper is used instead of muslin.

Preparation of Earthworms for Dissection.— Fresh specimens are too soft for convenient handling of the tissues during dissection; it is also inconvenient to keep a sufficient number of them alive for general dissection purposes; hence preservation is resorted to. Two methods are available: —

(*a*) *Chromic Acid Method.*

1. *Killing.*— Place in 4% alcohol and gradually increase the strength to 8% in the course of the next two hours by adding stronger alcohol a few drops at a time. Wash in water to free from mucus and again immerse in 8% alcohol until the worms are thoroughly stupefied and no longer contract when pinched with forceps.

2. *Fixing.*— Inject worms with 1% chromic acid and immerse in the acid for about 4 hours.

The injection is best performed by means of a water pressure apparatus (see Fig. 1). This gives constant, uniform pressure. A head of about four feet of water should be used. A glass cannula may be made by drawing out the end of a piece of $\frac{1}{4}$ inch glass tubing to a very fine bore, and breaking it so as to leave a sharp point with a raw edge. The exact size must be determined by experiment. The stream may be allowed to flow continuously from the cannula. A pipette with point drawn out fine may be used in case this apparatus is not available, but it is not very satisfactory.

[1] H. S. Jennings. "Keeping Earthworms Alive in Winter." *Journ. of Applied Micr.*, vol. 6, no. 7, pp. 2412–2413.

Fill a large shallow glass dish about ½ inch deep with 1 % chromic acid. (Cover the hands and wrists thickly with vaseline while working with chromic acid.) Take each worm separately and lay it in an extended condition in the chromic acid, keeping it straight and seeing that it is not twisted. Inject immediately,

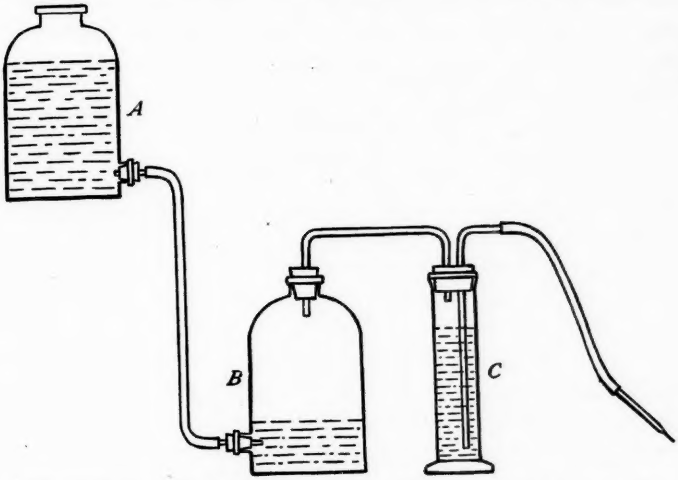

FIG. 1.—Constant pressure injection apparatus. *a* should be filled with water, part of which flows into *b*; *c* contains injection fluid.

about ½ inch behind the clitellum, and again near the posterior end of the body if necessary. *Inject into the body cavity; be careful not to pierce the alimentary canal.* The worm should swell out slowly along its entire length and become very turgid. Too rapid injection may tear the tissues.

The worms should be kept straight while in chromic acid. If left in the acid less than four hours they will eventually become too soft; if left in the acid much more than four hours they will be too brittle.

Wash thoroughly in running water until the yellow color is gone — about 12 hours. Be sure that the water reaches every part of the surface of each worm. If free acid remains on the worms it will make them brittle. The worms are a light drab, not yellowish brown, when well washed.

3. *Preserving.*— Place the worms in 50% alcohol and leave for a day or two; the alcohol will become discolored by chromic acid. Change to 70% and leave a day or two longer. Then change to the same grade (70%) for final preservation.

The alcohol will complete the process of removing free acid and will further harden the tissues. Stronger grades of alcohol than 70% are not advisable for preservation, as they may cause the more delicate tissues to become brittle.

(*b*) *Alcohol Method.*

Kill as directed under chromic acid method. Place the worms in 50% alcohol, keeping bodies as straight as possible. Leave 4 or 5 hours, then place in 70% alcohol and leave over night. Next morning place in 96% alcohol to harden them, and leave all day. Change to 70% alcohol for final preservation.

Choice of Methods.— Specimens hardened in chromic acid are most satisfactory for general dissection purposes. The tissues are firm and leathery, and are not affected by water during dissection, hence they may be dissected under water instead of alcohol. This is a decided advantage. The largest and best marked specimens should be put up in this way.

The alcohol method of fixing is not so satisfactory for most purposes; the body wall and tissues generally are too soft to be conveniently handled unless the dissection is done under alcohol. But the method has the advantage of simplicity, and the smaller and more poorly marked specimens may be put up in this way for use in case other material runs short. Alcoholic specimens do very well for the study of the nervous system.

Fresh specimens are not only necessary for the study of the living worm, and for demonstrations of cilia, blood, cœlomic fluid, spermatozoa, etc., but are best for the study of the circulatory system and the nephridia.

For studying the circulatory system the living specimen may be stretched out in a dissecting tray and fastened with a pin through each end of the body; if desired it may first be stupefied with alcohol. The dissection should be carried on under

normal salt solution (0.75 % NaCl). In the absence of living specimens, chromic-acid specimens do fairly well for the circulatory system.

For sectioning with a microtome it is necessary to have specimens with intestines entirely free from grit. Worms that have been kept in clean, moist muslin for a considerable length of time will usually be found to have the alimentary canal free from all undesirable substances. The muslin should be changed every day, and the worms must not be fed. A quicker method [1] is to flush the alimentary canal by means of an injection apparatus. Use a cannula with a rather large opening; the proper pressure must be determined by experiment. Stupefy the worms with dilute alcohol (3 to 6 %). Inject the alimentary canal from the posterior end with 0.75 % salt solution; roll the body of the worm back of the clitellum between the fingers and strip out the contents of the intestine. Then inject from the anterior end; this time the stream will go entirely through. Avoid too much pressure, as it will injure the tissues. Roll and knead the body while the stream is being started through. The fluid should be forced through the worm until it comes from the posterior end in a perfectly clear stream. The worm is then ready for fixing.

Zoölogical Laboratory, University of Michigan,
Ann Arbor, Mich.

[1] Raymond Pearl. *Journ. of Applied Micr.*, vol. 3, no. 1, p. 680.

A NEW OSTRACOD FROM NANTUCKET.

JOSEPH A. CUSHMAN.

DURING the spring of 1905, several members of the Nantucket Maria Mitchell Association made collections from the various bodies of fresh water on the island. This material was kindly turned over to me for study. Among other noteworthy things is an ostracod of the genus Cyprinotus that is apparently new. Its description follows: —

Cyprinotus americanus sp. nov.

Plate 1, Figs. 1–8.

Length of male 1.5 mm., width 0.7 mm., height 0.8 mm.

The length of the shell is a little more than twice the width and the height is slightly greater than the width. The shell is thin, translucent, free from bands or color markings of any sort (Pl. 1, Fig. 1).

Viewed from the side (Pl. 1, Fig. 1) the shell is suboval, with the greatest height slightly more towards the cephalic end. The dorsal margin is convex, the cephalic end much more convex than the caudal, which is almost bluntly pointed. The ventral margin is also slightly convex.

Viewed from above (Pl. 1, Fig. 2) the shell is narrowly elliptical with the anterior end more rounded than the posterior.

The third joint of the antenna is toothed on the distal part of each side, with one of the angles clothed with fairly long hairs. The single seta from this angle is doubly fringed. The last joint is short and bears two of the four terminal claws, these latter being finely toothed. The natatory setæ extend to the end of the terminal claws. The characters of the antennules are shown in Fig. 4 (Pl. 1). The setæ from the last joint are much shorter than those from the preceding ones. The characters of the mandible are very distinctive. The setæ of the upper joint are peculiar, all of them being doubly fringed with scattered hairs. The large terminal setæ are fringed on a single side. The third joint has many short spines on its ventral side. The jaw of the mandible has compound teeth of which the anterior ones are comb-like in structure.

The first foot has a long terminal claw the distal part of which is finely toothed. The fourth joint bears four short spines. The second joint has

two long curved spines in addition to the setæ. The second foot has a peculiar claw-like extremity. The last joint is constricted in the middle and the distal portion bears two rows of minute spines.

The rami of the postabdomen have two long claws, finely toothed along their whole length. The proximal small seta is considerably removed from the others.

Habitat. — Specimens collected from Grove Lane Ditch near the town of Nantucket, Mass., April 30, 1905, by Miss Marianna Hussey.

In many ways this species most closely resembles *C. burlingtonensis* Turner but is different in its proportions and in the distribution of the setæ on the appendages as well as in their spinosity, and the shape and setæ of the mandible.

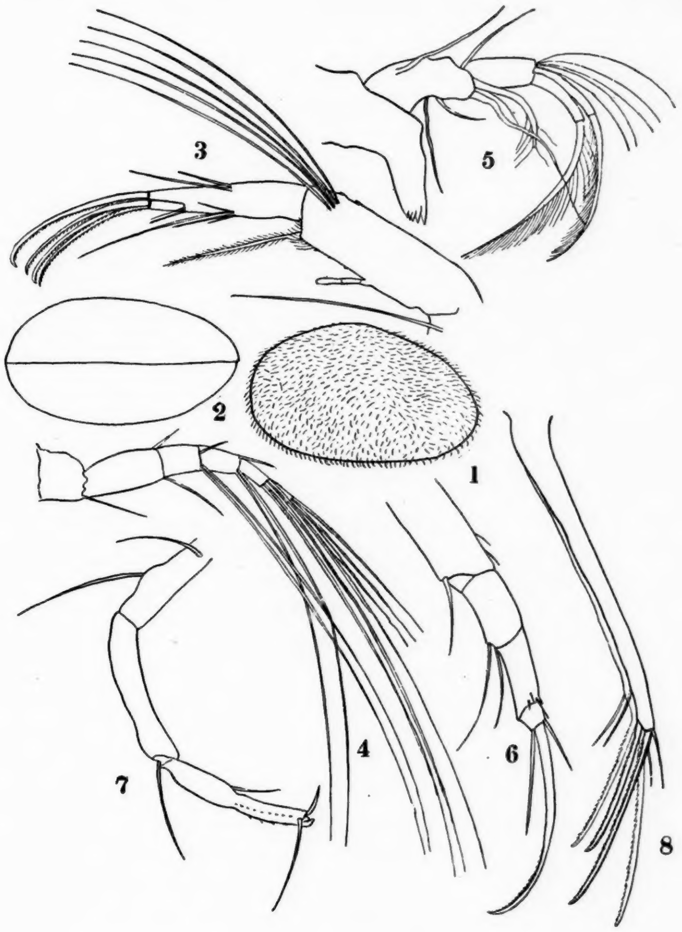

PLATE I.

Fig. 1.— Shell viewed from the side. × 40.
Fig. 2.— Shell viewed from above. × 40.
Fig. 3.— Antenna. × 200.
Fig. 4.— Antennule. × 200.
Fig. 5.— Mandible of another species placed on this plate by mistake.
Fig. 6.— First foot. × 200.
Fig. 7.— Second foot. × 200.
Fig. 8.— Abdominal rami. × 200.

FURTHER NOTE ON *HYLA ANDERSONII* AND *RANA VIRGATIPES* IN NEW JERSEY.

WILLIAM T. DAVIS.

In Cope's *Batrachia of North America*, and in other works treating of our native frogs, *Hyla andersonii* Baird is said to be rarely met with. In the note on this species by the writer published in the *American Naturalist* for November–December, 1904, that view was also taken, but it must now be accepted as a fact that *Hyla andersonii* is anything but a rare frog in certain parts of the New Jersey pine barrens.

At Lakehurst, New Jersey, especially in the latter part of May and in June, there may be heard at evening coming from the white cedar swamps, many voices that resemble the familiar quacking of ducks. If one will take the trouble to wade into one of these swamps at twilight and approach the singer cautiously, it will be discovered that he is a male *Hyla andersonii*. He pipes up and sings "*aquack-aquack-aquack*" many times, or until his bubble of air gives out. This is the time, while he is singing, to take a step forward. Even when the observer is very near and evidently plainly in his view, he cannot resist the temptation to sing, for he hears his rivals all about calling loudly. The notes are not all alike in sound, and some individuals remind one of the "*potrack-potrack*" of the farmyard Guinea fowl. The Hyla will be found seated on the lower limb of some tree, or among the top branches of a huckleberry bush. I have heard this frog singing at mid-day when the sun was shining brightly, especially after a shower. Also solitary individuals may be heard in the swamps much later in the year, and they do not appear to wander as far from the water as does *Hyla versicolor*.

Rana virgatipes Cope is also more abundant at Lakehurst than at first supposed, and has been found from May to September. In the early summer as many as twelve have been seen in one day without much search having been made for them.

They are apt to be in some ditch and seated on the sphagnum moss, or on a floating lily pad, and they are found also in the ditches that border and intersect the cranberry bogs, as well as in the lake.

A SYSTEMATIC STUDY OF THE SALICACEÆ.

(*Concluded.*)

D. P. PENHALLOW.

ANATOMY.

The Growth Rings.— So far as may be judged from an examination of fifteen species of Salix and eleven species of Populus, growth rings of somewhat great radial extent appear to be a general characteristic of the Salicaceæ. Such a feature is directly correlated with, and in fact may be taken to be a resultant of the very free growth for which the members of this family are, in general, conspicuous. Partial exceptions have been observed in the medium growth rings of *Populus balsamifera*, *P. monilifera*, and *P. heterophylla*, as also of *Salix scouleriana*; but slight deviations of this nature cannot be regarded as expressing a general law, since as has been shown by Peirce (:04), they may well have arisen in response to injuries inflicted by insects or other agencies, or they may simply be an expression of periodicity in climatic conditions. The same statement cannot be said to hold true in equal measure of *Populus alba* and *P. grandidentata*, since in both of these species the generally narrow and uniform growth rings seems to point to specific differences. These observations are greatly strengthened by the fact that *Salix uva-ursi* presents a noteworthy deviation from the general characteristics of the family. Its growth rings are not only narrow, but they are variable and strongly eccentric. Such characteristics are very readily understood when the natural habitat of this plant is recalled. Growing in the Alpine Garden on Mt. Washington at an elevation of about five thousand feet, its development is accomplished under the influence of a very short season the character of which must vary in an exceptional manner from year to year, while the prostrate habit would also establish marked eccentricity of

growth. This case is therefore to be regarded as lying outside the normal course of development for the family as a whole, while at the same time it serves to give emphasis to the specific effects of external influences in modifying the character of the growth.

It is a general feature of the Salicaceæ to which there are no well defined exceptions of a noteworthy character, that there is substantially no differentiation of spring and summer wood. Partial exceptions seem to be shown by *Salix longifolia* in which the last six rows of cells sometimes become radially compressed, or by *S. cordata* and *S. lævigata* in which three rows are sometimes so modified. The fact that in all these cases the modification is not a constant feature, but that it arises sporadically, indicates clearly that it is due to some exceptional and transitory influence, and that it does not in any way express the usual characteristics of growth. On the contrary, it is not an uncommon feature in *S. nigra* for the first half of the growth ring to present the most dense structure, this being due, not to a diminution of the vessels with a relative preponderance of the fibrous mechanical cells, but to the fact that the latter are characterized by thicker walls than elsewhere, with a corresponding diminution of the cell cavity. In the investigated species of poplar, there seems to be no deviation from the general rule thus expressed. In both genera there is substantially no alteration in the form and size of the wood cells as between those of the inner and those of the outer face of the growth ring (Figs. 6, 7), and the demarcation between the growths of successive seasons is determined by other factors of which the occurrence of a limiting zone of resinous wood parenchyma is the most important. From these considerations it appears that the character of the growth ring, in its more general aspects, possesses no diagnostic value for specific purposes, or even for generic differentiations, but that it may be regarded as of value for ordinal purposes with respect to their great breadth and the absence of any marked differentiation between the spring and summer woods. Since the radial compression which is generally so distinctive a feature of the summer wood, is recognized to result from increasing cortical pressure (De Bary, '84, p. 501) it must

be inferred from the observed structural conditions, that in the Salicaceæ as a whole, the bark expands or ruptures in such a way as to provide a minimum of pressure which is practically uniform during the entire period of growth.

The Transition Zone.— The protoxylem region in the Salicaceæ, or what may with more propriety be termed the *transition zone* in accordance with the previous use of that term (Penhallow, :00, :04c), is exclusively confined to the growth of the first year in accordance with the general law of growth which governs the Dicotyledonous angiosperms, and the following observations must therefore be interpreted in that sense.

So far as our studies have gone, they show that in the arborescent Salicaceæ, whether Populus or Salix, the transition zone is narrow and that it consists almost exclusively of a few spiral and scalariform elements. I have as yet been unable to discover in such forms, any extension of the protoxylem which would admit of transitional forms of the elements. The transition from the primitive protoxylem elements on the one hand, to completed forms of wood cells without pits, and of broad vessels with hexagonal pits on the other hand, appears to be developed with great abruptness. These features appear to be so well defined and constant as to make it apparent that the transition zone has been so far reduced as to approach the point of actual extinction.

In 1897 an opportunity was presented to collect some stems of *Salix uva-ursi* from the Alpine Garden, Mt. Washington. At that elevation the greatly reduced shrubs are forced to assume a prostrate habit of growth, in consequence of which the rather slender and somewhat sinuous stems are buried under a considerable accumulation of plant *débris*. In such situations, although there is usually an abundance of water during the summer, the plant is of a somewhat xerophilous habit as made evident by the reduced and somewhat coriaceous foliage, in obedience to the low temperature and the consequent inability of the roots to provide for an actively moving transpiration current, as pointed out by Schimper (:03). This xerophilous habit is also expressed in the general structure of the wood as may be observed by reference to the diagnosis, from which it will be

noted that the vessels are very small and there is a relative preponderance of the mechanical tissue. Assuming that the willows originated under the influence of a relatively warm climate as we have reason to believe must have been the case on the basis of evidence brought forward by Wieland (: 03), it is evident that *Salix uva-ursi* in common with other boreal and alpine forms, must represent a degenerate type which has been reduced under the influence of a diminishing temperature. But such reduction has clearly involved a loss of the originally erect position, and in consequence of the diminished necessity for mechanical support, it might be inferred that there would be a more or less pronounced tendency to reversion in such wise that the transition zone would tend to regain its primitive character to some extent, and that it would once more exhibit those developmental features of structure which have essentially disappeared from the great majority of species as now known. It was therefore felt that this plant might offer exceptional opportunities for a solution, in part at least, of the question as to the actual genesis of the vessels and the wood cells, and their mutual relations. The stem selected for study was of a somewhat sinuous form and in cross section ovate, the diameters being 1.20 and 1.80 cm., with the pith eccentrically placed toward the narrower or under side, the major axis of the cross section being oriented vertically. Longitudinal sections were cut from this stem at a slight angle with its principal axis, and in such number as to embrace not only the entire pith, but a considerable portion of the secondary xylem lying on opposite sides. It will thus be observed that while some of the sections were strictly radial, their character gradually changed as the relation of the plane of section to the radius changed, until they became strictly tangential. It thus became possible to study the elements of the transition zone from these two points of view and in a progressive series. But owing to the slight inclination of the plane of section to the longitudinal axis of the stem, the same section would exhibit at one end the radial aspect and at the other end the tangential aspect, while between the two there would be a graduated series of changes showing all details in the entire radial extent of the transition zone. This

was found to be of special importance because the protoxylem is so localized and forms such small groups, while the transition elements are so scattered, that many radial sections might be examined without furnishing conclusive results. The diagonal plane of section, on the other hand, cuts through the entire radial extent of the transition zone and is certain to display whatever transition forms may be present. In this way it was possible to obtain the figures now presented.

The rather scanty pith is composed of isodiametric and somewhat thick-walled cells of large size, which, at the periphery, become greatly reduced in size without any diminution of the absolute thickness of the walls, assume the form of short cylinders, and function as resin-bearing parenchyma. There is thus produced a strongly resinous zone of tissue in immediate contact with the protoxylem and enclosing it on the radially inward face as well as the two tangential faces. It is not difficult to determine that the protoxylem consists primarily and chiefly of the usual spiral and scalariform tracheids which are common to the same zone in others of the Salicaceæ; but a careful examination of the diagonal section shows that there are other elements of a transitional character not to be met with, so far as I am aware, in other species having an upright habit of growth. A somewhat detailed account of the features noted will be essential.

The protoxylem elements proper consist of a few spiral tracheids characterized by very flat and close spirals. Such elements commonly have very abrupt and often transverse terminations. The length varies very much, so that while in most cases long, they are also not infrequently very short. As exposed in section on the tangential walls, the spirals are seen not to be simple bands, but to be broadest in the part which was most recently formed, and therefore most remote from the primary wall. The general effect of this is to give to the sectional view of the wall, the appearance of a continuous series of contiguous, bordered pits. This fact also makes it clear that the spirals of Salix have lost the simple and primitive character of those bands which are to be met with in the protoxylem of the gymnosperms, or even in many of the vessels of the Monocotyledons, and that they

have distinctly approached that modification which must immediately precede the formation of bordered pits. Such a feature serves to show that the transition from spiral to scalariform structure might be accomplished without any very conspicuous transitional forms such as have been shown to exist in the case of Cordaites, and such as are found not to exist in the Salicaceæ as a rule; while it also serves to explain in part the great radial diminution of the protoxylem of the Salicaceæ as compared with that of more primitive forms of plants. In addition to the spiral tracheids, the protoxylem also includes a certain number — generally few — of scalariform elements. These approximate in form and size to the spiral tracheids though they often have distinctly tapering extremities, in which respect they approximate very closely to the fibrous mechanical elements or wood cells of the secondary xylem (Fig. 1). It has also been observed in such cases, that the scalariform markings become distinctly fewer and more distant (Fig. 1) as if certain of the pits had been obliterated by a more general secondary thickening of the wall, and that such is the true explanation we are justified in believing from a study of the transition zone in Cordaites (Penhallow, :00, :04c). That such obliteration has not proceeded at a uniform rate throughout the length of the cell, is evident from the figure given. When such scalariform markings are exposed in section, they exhibit precisely the same bordered structure as in the case of the spirals. The most interior portion of the secondary xylem sometimes contains scalariform elements of a transitional form. In such cases the scalariform structure is irregular and very imperfectly developed upon both the radial and the tangential walls, presenting an obvious form of transition in the direction of the bordered pits, chiefly expressed in the shortening of the individual pits and their more definite segregation. But such changes in the structure of the cell wall might equally well be precedent to the complete and final obliteration of the pits of whatever form,

FIG. 1. — *Salix uva-ursi*. Tangential section of a scalariform tracheid showing transitional form. × 350.

a view which is justified not only by the reduction in size and number of the scalariform markings, but by the irregular manner in which such reduction proceeds, so that the pits often lack that regular and definite disposition so characteristic of the bordered pits; and finally it is justified by the fact as shown in Fig. 1, that the scalariform markings are often wanting on the radial walls while characteristically developed on the tangential walls.

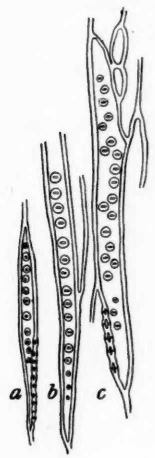

FIG. 2.—*Salix uva-ursi.* Tangential sections of tracheids with bordered pits, showing transitional forms in the direction of fibrous wood cells. × 350.

The earliest secondary xylem is characterized by the presence of true fibrous tracheids distinguished by the presence of bordered pits. These tracheids as shown in Figs. 2 and 3, are all tapering or of the fibrous and fusiform type, and they vary very much in length and breadth. In those of the most slender form, there is but a single row of bordered pits which diminish very greatly in size as the end of the tracheid is approached (Figs. 2, *a*, *b*). With an increase in breadth and usually a corresponding diminution of length (Fig. 2, *c*), there is a strong tendency to a multiseriate arrangement which becomes fully expressed in the completely developed vessel as shown in Fig. 5. In such fibrous tracheids, there is considerable variation in the distribution of the bordered pits. Thus we find many instances of pits on both the radial and tangential walls (Fig. 3), a distribution common to the vessels as shown in Fig. 5, although it will be noted that when such a vessel abuts upon a fibrous wood cell, there are no bordered pits on the radial wall common to the two. This fact is expressed in other ways. Thus in the case of the fibrous tracheids in Fig. 2,

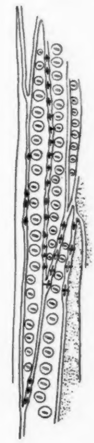

FIG. 3.—*Salix uva-ursi.* Tangential section showing transitional forms of tracheids with bordered pits on both the radial and the tangential walls, and resinous wood cells. × 350.

it will be seen that the pits are confined chiefly to the tangential walls, and appear on the radial walls at the ends only of the tracheids (Figs. 2, *a*, *c*), or they may even be completely eliminated from the radial walls as in Fig. 2, *b*. Such variations are also to be seen in Fig. 4. One variation of such relations worthy of note, was found in radial section. A spiral tracheid of the protoxylem was immediately followed on its outer side, by a fibrous tracheid with round, variably distant bordered pits in one series. The tangential wall common to the two was also provided with a continuous series of bordered pits. Immediately outside the fibrous tracheid, and therefore on the side opposite the spiral tracheid, was a fibrous wood cell presenting no pits of any kind upon either its radial or its tangential walls. The illustrations thus given in detail, serve to illustrate the general fact that all sorts of transitional forms are to be found, connecting the fibrous elements of the secondary xylem with the cylindrical and more or less tubular elements of the protoxylem; and it is quite evident that we have in *Salix uva-ursi* the same sort of a transition zone as that which has already been shown to exist in the gymnosperms (Penhallow, :00), the two cases differing chiefly with respect to (1) the radial extent of the zone, (2) the number and extent of the transition forms, and (3) the specific character of the final products. When we consider the various transformation stages occurring in *Salix uva-ursi*, the peculiar conditions of reduction in the structural details of the cell wall, the special alterations in the form of the individual elements, and the peculiar association of these derived forms, it is exceedingly

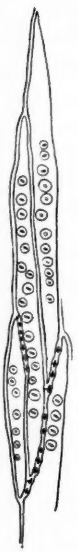

FIG. 4. — *Salix uva-ursi*. Tangential section showing various phases in the evolution of the fibrous wood cell through the pitted tracheid. × 350.

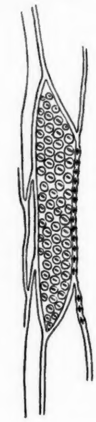

FIG. 5. — *Salix uva-ursi*. Tangential section of a vessel showing its relation to fibrous wood cells, the multiseriate bordered pits on both radial and tangential walls, and its deviation from the type of the fibrous tracheid. × 350.

difficult not to feel that we have before us an expression of evolution in two directions from the protoxylem, the one leading directly to the formation of vessels with multiseriate bordered pits; the other leading to the formation of purely mechanical and fibrous elements wholly devoid of pits, or in which the latter survive in the form of simple, sporadic perforations of small size. As far as it is possible to interpret the alterations of structure so far observed, the following would seem to be the sequence of events: —

Protoxylem.

Spiral tracheids with close spirals set at a low angle and showing a bordered pit structure in section. Terminations usually abrupt.

Scalariform tracheids with abrupt or tapering extremities; the markings showing a bordered pit structure in section. Transitional forms numerous. Markings often obliterated from either the radial or the tangential walls.

Secondary Xylem.

The elements diminish in length and increase in breadth.

The bordered pits on both the radial and the tangential walls are successively 1-, 2-, and multiseriate.

The vessels thus formed are multiplied in large numbers; they serve the purpose of circulation; they are reproduced as features of the secondary wood of each year's growth; they do not form a definite zone or medullary sheath after the first year; their functional activity may be arrested by the excessive development of thyloses or other causes; they constitute a relatively small portion of the entire structure; they contribute to the greater porosity and diminished strength of the structure as a whole.

The elements diminish in breadth and increase in length.

Bordered pits are at first present on both the radial and the tangential walls; at first one-seriate, they diminish in number and become more strictly segregated; they become more strictly confined to the radial walls; they eventually disappear; the secondary wall becomes of uniform thickness throughout, rarely with simple and minute pits. The mechanical elements or wood cells thus formed, are concerned solely with meeting the requirements of stress, to which end they are especially adapted; they constitute the chief part of the secondary xylem as of the secondary growth of the stem, to which they impart hardness, solidity, rigidity, and durability.

A comparison of these evolutionary phases with those already determined for Cordaites (Penhallow, :00, p. 57, and :04c, p. 250) will show that the two are essentially parallel, differing from one another only in detail in the two directions already indicated. So far then as the Salicaceæ are concerned, there is abundant supplementary evidence to show that in that family as well as in the gymnosperms, the evolution of the secondary xylem from the protoxylem is determined by the special requirements of support and the movement of the transpiration current; that the fibrous, non-pitted wood cells serving the ends of mechanical support, are derived from the spiral tracheids in the first instance; and that the relative predominance of mechanical or conductive tissue, is the *resultant* of influences acting along two distinct lines of development.

The Wood Cells.—Very little diagnostic value attaches to the appearance or disposition of the wood cells as presented in transverse section, and such features as they do exhibit are rather of ordinal than of generic or specific value. They are always hexagonal and very variable as to size. Usually they are disposed in a very irregular manner, though occasionally there is a more or less pronounced tendency to disposition in radial rows, but in no case is this so pronounced as in the Coniferæ — a difference which may be said to distinguish the gymnosperms from all the higher types of woody plants. The walls are of medium thickness, a feature which seems to be consistent with the generally soft character of the woody structure, and, as already pointed out, there is a complete absence of that unequal, regional, secondary growth of the cell wall which, in other woods, contributes so largely to a differentiation of the spring and summer woods. On the whole, the structure of the mechanical tissue is closely comparable with that of the Rhamnaceæ, a resemblance which will be found to extend to other features of the vascular zone.

Wood Parenchyma.—In its transverse section, the wood parenchyma varies considerably according to its position in the structure. Within the region of the medullary sheath the elements are more or less isodiametric; when associated with vessels, the tendency is to compression conformably with the

radius of the vessel; when forming isolated tracts, they tend to assume the form of the associated wood cells; but when occurring in the limiting zone of a growth ring where they are chiefly to be met with, they are invariably compressed in a radial direction, thereby assuming a form which serves to distinguish them from the associated mechanical elements.

In their longitudinal aspects there is little that is not common to such elements wherever they may be found. They are cylin-

FIG. 6.—*Salix alba*. Transverse section showing characteristic structure of the genus. × 52.

drical elements with somewhat thick and pitted walls, and abrupt or transverse terminations. In the medullary sheath they are generally only a few times longer than broad, but within the region of the secondary xylem, and especially in the limiting zone of the growth ring, they become much longer and proportionately narrower. Such features, however, whether exhibited in transverse or longitudinal section, are of an altogether gen-

eralized type, and they possess no value for differential purposes. The wood parenchyma is always characterized by the presence of resinous matter which is generally deposited in large quantity, and it thereby gives a distinguishing feature to the elements which admits of their very ready recognition. This is especially true of them in the region of the medullary sheath, but it is also equally true in some other cases.

The distribution of the resinous wood parenchyma as dis-

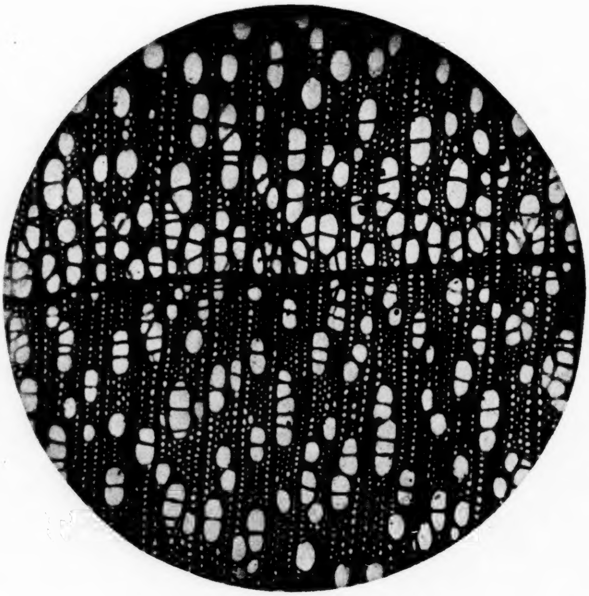

FIG. 7.—*Populus tremuloides.* Transverse section showing the characteristic structural features of the genus. × 52.

played in transverse section, presents features of special value for diagnostic purposes. In all of the Salicaceæ it forms a thin, limiting zone on the outer face of the growth ring. This zone varies somewhat in thickness and continuity, but as a rule it is composed of a continuous series of cells forming a layer from one to three elements thick (Figs. 6, 7). But in the

genus Salix, other features of importance for differential purposes are presented. Thus in *S. cordata* the cells occur in large numbers throughout the woody zone, and are distributed in such manner as to form rather conspicuous and often somewhat extensive tracts disposed without any reference to an orderly arrangement. In *S. sessilifolia* and *S. longifolia*, it not only occurs in the limiting zone, but it is also definitely associated with the

Fig. 8.—*Populus tremuloides.* Tangential section. × 52.

vessels as in *S. cordata*, forming about them a narrow but discontinuous layer, or as isolated cells at various parts of the periphery. All other species of Salix, so far as indicated by present investigations, have the wood parenchyma confined to the limiting zone of the growth ring, a rule which also seems to apply to Populus without exception.

The Vessels. — The chief diagnostic value of the vessels is to

be found in their distribution and compounding as exposed in transverse section, but before considering these features, it may be well to discuss the few details relating to their aspects in longitudinal section.

Thyloses are a general feature of the vessels in wood of the Salicaceæ, but they differ in some important essentials from those with which we are familiar in other woods, *e.g.*, Catalpa or Pinus. They generally fill the cavity of the vessel so completely (Figs. 6, 7) that in transverse section they seem to be entirely wanting. This is due to the fact that they undergo no longitudinal division, and as a result there is only one thylosis transversely, which is closely applied to the wall of the vessel. It will nevertheless be observed that in longitudinal section, instead of the modified spherical form usually assumed in woody stems, the thyloses of the Salicaceæ are really in the form of long, cylindrical cells several times longer than broad, but of very variable length. It is this last feature among others, which results in their apparent absence from the transverse section, since a given plane of section is most likely to pass between terminal walls, and as the thyloses lie in a single series, there are no longitudinal walls to break up the cavity of the vessel.

Apart from the well known structure which distinguishes all the vessels of the wood in angiosperms, it will be found that the radial walls are characterized by bordered pits which are chiefly somewhat distant, sometimes conspicuously so, and in consequence they are either oval or round (Fig. 10). It is rather the exception that they are so aggregated as to become hexagonal. On the other hand, in the tangential section, the pits are invariably crowded together to such an extent that they are typically hexagonal (Fig. 11), and the space between contiguous pits is represented by only a very narrow line of secondary wall joined directly to the primary wall. These differences will be found in exact accord with the distribution of the pits on the radial and tangential walls as described for the transition zone, and they seem to imply that the transverse movement of the transpiration current must be somewhat more energetic in a tangential than in a radial direction, contrary to what has been found to be the case in the Coniferales.

In transverse section the distribution, form, and compounding of the vessels impart to the structure an appearance quite similar to that found in the Rhamnaceæ. This very striking resemblance is likely to result in confusion unless very careful attention is given to details; and the likelihood of error from this source is all the more probable when it is observed that there is also a strong similarity of structural detail in radial section. It is, however, not our purpose to discuss these resem-

Fig. 9.—*Salix alba.* Tangential section. × 52.

blances at the present moment, since the essential differentiations of the two families will be sufficiently emphasized by their separate study. In the Salicaceæ the vessels give to the entire structure a high degree of porosity which is extended more or less uniformly to the entire thickness of the growth ring (Figs. 6, 7). This general law is subject to variation in detail. Thus

in such types as *Salix alba* (Fig. 6), *S. lævigata*, or *S. longifolia* they are so abundant as to give the impression of predominance, an impression which is greatly strengthened in *S. lasiandra* where the vessels justify the description of "strongly predominant throughout." The same law of distribution also applies to the poplars, though with the very essential difference that while in Salix there appears to be no very essential numerical reduction as between the initial zone and that which terminates the growth ring (Fig. 6), in Populus on the contrary, the initial zone usually shows a great increase in numbers with a more or less gradual diminution toward the termination of growth for the season (Fig. 7). This is fully expressed in such species as *P. alba*, *P. wislizeni*, *P. angustifolia*, etc., but in *P. monilifera* there seems to be a predominance which is fully maintained until the region of the summer wood, when there is an abrupt reduction.

The form of the vessel is typically oval in a radial direction (Fig. 7), but this is sometimes varied to oblong as in *Salix alba* (Fig. 6) or *S. lævigata*, or to broadly oval as in *Populus heterophylla*, or even to transversely oval as in *P. alba*. While in general, the vessels are largest in the initial growth of the season, the diminution in size toward the outer face of the growth ring may proceed gradually and without any very marked alteration as in *P. tremuloides* (Fig. 7); they may become abruptly smaller as in *P. fremonti*, or they may exhibit a graduated diminution as in *S. uva-ursi*.

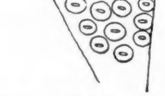

FIG. 10.—*Populus tremuloides*. Radial section showing the round or oval and distant bordered pits. × 350.

One of the most striking features of the vessels in the transverse section, is their peculiar compounding, a feature also similarly expressed in the Rhamnaceæ. Such compounding in the Salicaceæ always occurs in such manner as to give rise to radial series (Figs. 6, 7) and in the various forms of complexity thus arising, it constitutes within certain limits, a valuable differential character for the various species. Thus in *Salix longifolia*, *S. discolor*, *S. uva-ursi*, *Populus*

alba, *P. fremonti*, *P. pyramidalis*, *P. balsamifera*, etc., the large, oval vessels later become reduced in size, but they chiefly remain single or become sparingly 2-compounded. In *Salix alba* (Fig. 6), *S. sessilifolia*, or *S. brachystachys*, the vessels are chiefly 1-, 2-, or rarely 3-compounded; in *S. nigra*, they are rarely 8-compounded; in *S. lasiolepis* they are chiefly single throughout; in *S. lancifolia* they are rarely 4-compounded; in *Populus fremonti* they are rarely 5-compounded, and similar variations are to be met with throughout the entire family, always with the status of specific characters. While the general facts are thus noted, it will be sufficient to refer to the various diagnoses for an amplification of such details. It is only occasionally that the vessels assume a definitely resinous character. This is expressed among the species so far investigated, only by the unusually resinous *Salix cordata*, the vessels of which are everywhere resinous.

Medullary Rays.—As in the Coniferales so in the Salicaceæ, the medullary ray presents some of the most important of all the structural features for diagnostic purposes. Their value is of both a generic and a specific character. They are expressed in both radial and tangential sections which it will be desirable to discuss separately somewhat in detail.

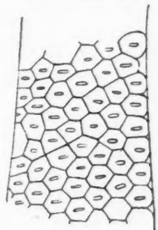

FIG. 11.—*Populus tremuloides.* Tangential section showing the multiseriate and hexagonal bordered pits. × 350.

In their tangential aspects the medullary rays of the Salicaceæ may be described as chiefly narrow; 1- or more rarely 2-seriate in part. From this there is no essential deviation which applies to one genus more than to the other, except in so far as variation is rather more characteristic of Salix, and constancy more characteristic of Populus. It may be said that broad rays, or rays with oval or transversely oval cells, and 2-seriate rays are more common to the former than to the latter. Such differences will be made sufficiently clear by a comparison of Figs. 12 and 14, and Figs. 12 and 15.

One of the chief factors in the tangential section of the ray, is the occurrence of ray cells of two kinds and the possibility of distinguishing them from one another. These cells will be

referred to as (1) and (2), and their more detailed characteristics will be discussed in connection with the radial section. In the genus Populus, as clearly shown in *P. tremuloides* (Figs. 12, 13), there is no clearly defined distinction between the two kinds of cells by means of which each may be recognized beyond question. In Fig. 13, the distinction is clear by reason of the distribution of the resin and the special location of each kind of cell. Thus the more resinous cells, *a*, occupying the central region, are of the first order (1), while the less resinous cells, *b*, occupying the extremities of the ray, are of the second order (2). This differentiation serves to illustrate the general law that the cells of the first order are usually the more strongly resinous, and that the less resinous cells of the second order are chiefly terminal unless also interspersed. But such distinctions are not always valid, even in the same species, since in Fig. 12, taken from the same section, the non-resinous terminal and interspersed cells, *b*, are probably all of the second order, while the more resinous cells, *a*, are chiefly of the first order. But the three resinous and terminal cells of this figure involve considerable doubt as to their precise character, inasmuch as their positions would lead us to assume that they must be of the second order in spite of their resinous contents, a view which gains force from what may sometimes be observed in radial section.

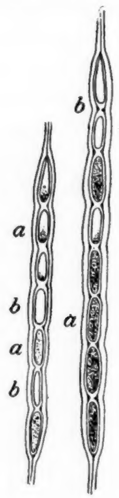

FIG. 12. — *Populus tremuloides.* Tangential section of the narrow medullary rays. *a*, cells of the first order; *b*, usually non-resinous cells of the second order. × 350.

FIG. 13. — *Populus tremuloides.*—Tangential section of a medullary ray with broader and resinous cells of the first order, *a*, clearly distinguishable from the non-resinous and somewhat narrower cells, *b*, of the second order. × 350.

In the genus Salix (Figs. 14 and 15), where the structure is of a more decidedly resinous character, the cells of the medullary rays are usually all resinous, and this feature serves no useful purpose in differentiations. We do find, nevertheless,

that in position and form, as also usually in size, there are differential features of well defined value. Thus in *Salix longifolia* (Fig. 14) there is no room for hesitation between the round or transversely oval cells, *a*, of the first order constituting the bulk of the structure, and the oblong narrow and terminal cells, *b*, of the second order. Or again in the same species (Fig. 15), the same difference appears in the 2-seriate form of the ray. In low rays, the tendency is for the cells of the first order to be replaced by those of the second order as also shown in Fig. 15 on the right. From these considerations it will be obvious that the distinctness with which these two forms of cells appear in the tangential section is of importance as a basis of generic differentiation.

FIG. 14.—*Salix longifolia*. Tangential section of a medullary ray showing the resinous character of the cells; the round or chiefly transversely oval form of the cells of the first order, *a*, and the larger and narrower cells, *b*, of the second order, the two forms of cells being sharply differentiated. × 350.

A second factor of value is to be found in the form of the ray cell and its variations. In the genus Populus, the cells of two kinds present little or no difference in form by which they may be distinguished from one another. This is especially true of *P. balsamifera*, *P. heterophylla*, *P. monilifera*, etc., while in *P. tremuloides* (Fig. 13), *P. alba*, *P. pyramidalis*, *P. grandidentata*, etc., there is a somewhat obvious difference in many cases which, taken in conjunction with other features, serves to bring such species into a separate group. Thus

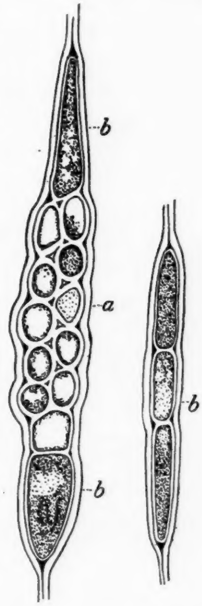

FIG. 15. — *Salix longifolia*. Tangential section of two rays, the one showing the 2-seriate form embracing cells of the first order, *a*, together with larger terminal cells, *b*, of the second order, the two clearly differentiated; the other showing a low ray entirely composed of cells, *b*, of the second order. × 350.

it will be found that where such differences exist, the cells of the second order are generally narrower and relatively or absolutely longer. The cells of the first order are, as a rule, chiefly narrow and oblong. Few exceptions to this occur (Fig. 15) though they may appear not only in the same species but also in the same section. On the whole it may be said that Populus is generally characterized by narrow and oblong cells — the tendency to an oval or round form being of the nature of an exception. In the genus Salix, on the contrary, the typical form of the cell (1) is oval, round or even transversely oval (Figs. 14, 15), the occurrence of narrow and oblong cells being of the nature of an excep-

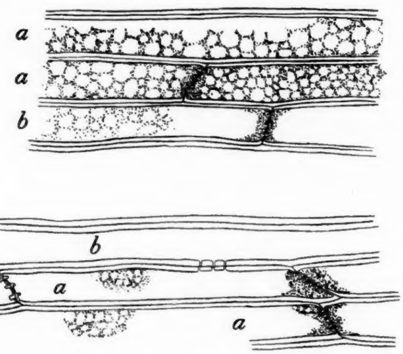

FIG. 16.— *Populus tremuloides.* Radial section of medullary rays showing the often resinous character and structural details in cells of the first order, *a*, and the second order, *b*. × 350.

tion. The cells of the second order (2) are also much longer and narrower than in Populus, differences which will be readily explained by the radial sections, so that considering these differences as a whole, they again afford a valuable element in generic differentiations.

The radial aspect of the medullary ray is, in many respects, the most important for diagnostic purposes inasmuch as it exhibits very striking differences of structure and form which are not only of generic but of specific value. These differences are expressed most prominently in the form and character of the cells whereby it is necessary to recognize cells of two kinds. Fundamentally the ray is composed of cylindrical cells several

times longer than broad, and either of uniform width throughout or somewhat contracted at the ends. The terminal walls are always more or less strongly pitted, but they exhibit somewhat striking variations in this respect as between Salix (Fig. 17, *a*) and Populus (Fig. 16, *a*). The upper and lower walls are rather thick and often strongly pitted, but in both of these respects there is a marked difference between the two genera in such a way that in Populus (Fig. 16, *a*) there is always a tendency to a relatively thin wall with few pits, while in Salix (Fig. 17, *a*) the tendency is always toward a very thick and strongly pitted wall. Such cells are generally resinous, more strongly so in Salix than in Populus, and it is in them that resin is found when it may

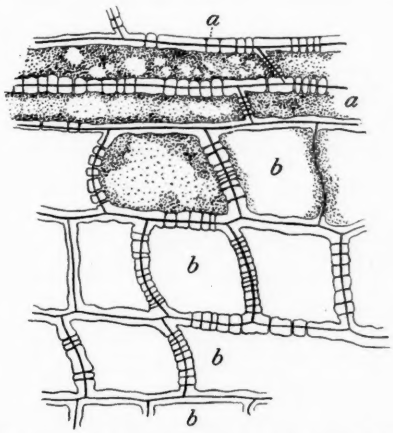

Fig. 17.— *Salix hookeriana.* Radial section of a medullary ray showing details in the structure of the cell walls; cells *a* of the first order, and cells *b* of the second order, the latter occupying a marginal position. × 350.

have been eliminated from all other parts of the ray. Such cells I have designated as "cells of the first order" or (1). They seem to be the more primitive parts of the structure, and in this sense they are comparable with the parenchyma cells of the gymnosperms (Penhallow, :04c). Their radial walls are generally devoid of pits except that in a few instances I have observed the occurrence of minute and simple pits opposite wood cells, but so far as can be ascertained at the present time, this feature possesses no special significance.

Together with the cells of the first order, cells of a somewhat and often wholly different character appear. In the genus Populus, this differentiation is expressed with the least force, and it is difficult or even impossible to distinguish between the two except through certain special structural features of the radial walls. Such cells are, generally speaking the least resinous. To all such I have applied the designation "cells of the second order" or (2). An inspection of Fig. 16 taken from *Populus tremuloides*, will show that there is essentially no distinction as to form and structure, between cells of the first order, *a*, and those of the second order, *b*, and it is only when we study such cells opposite vessels that the distinction becomes obvious. In such regions cells (2) invariably show either oval (Fig. 18) or quadrangular pits (Fig. 19) disposed in somewhat definite radial series. Such pits and of the forms described, are characteristic of the genus Populus, and from this there is no essential deviation so far as our investigations have proceeded. These features make it clear why the tangential section of a ray in Populus does not give a clear differentiation of the two kinds of cells. In the genus Salix the case is very different. There we always find the ray characterized by the presence of cells which are very much shorter and very much higher, so that they become isodiametric (Fig. 17, *b*). But it also very often happens that the alteration thus indicated is subject to extreme exaggeration in such a way that the cells become several times higher than long, and therefore *high and narrow*. This is a feature peculiar to Salix, and it has not been observed in any form in Populus. It is this very strong difference in form, as well as the very striking variations in size among the cells of the second order, which serves to establish so strong a differentiation between the two kinds of cells as exposed in tan-

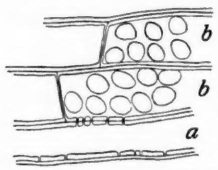

FIG. 18. — *Populus tremuloides*. Radial section of cells of the second order (2) showing oval pits on the lateral walls opposite vessels. × 350.

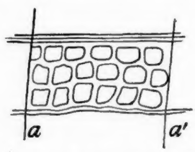

FIG. 19. — *Populus tremuloides*. Radial section of cells of the second order, (2) showing quadrangular pits on the lateral walls opposite vessels. × 350.

gential section. In addition, however, the cells (2) are always characterized by their peculiar pits on the radial walls when opposite vessels. These pits are very rarely of the oval or quadrangular form presented by Populus. On the other hand they are more or less definitely angled and crowded as typically presented by *Salix alba* (Fig. 20.) But such a form is subject to very marked and significant variation. Thus in such types as *S. sessilifolia*, the individual pits vary very greatly in size and form, sometimes being greatly reduced in size and multiplied in number, or again they diminish in number and increase greatly in size (Fig. 21); and not infrequently — indeed we might say that very often, even in the same species — there are all degrees of transition exhibited from the angled pit of *Salix alba* (Fig. 20) to typical scalariform structure in *S. sessilifolia* (Fig. 22). Such transitional forms are peculiar to Salix.

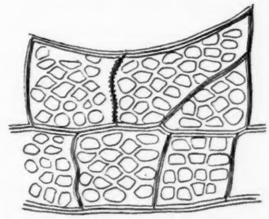

FIG. 20 — *Salix alba*. Radial section of cells of the second order (2), showing their form and the character of the angled pits on the lateral walls opposite vessels. × 350.

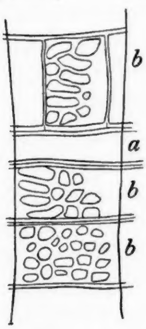

FIG. 21. — *Salix sessilifolia*. Radial section showing a cell, *a*, of the first order (1), and cells, *b*, of the second order (2) with variable, angled pits on the lateral walls opposite vessels, merging into scalariform structure. × 350.

In the genus Populus the distribution of the two kinds of cells is effected in such a way that those of the first order occupy the central region, while those of the second order occupy the margins above and below (Fig. 16, *b*, *b*; Fig. 13, *b*, *b*). Occasionally there is an interspersal with the cells of the first order (Fig. 12, *b*, *b*), but in such cases, as already pointed out, it is not always easy to distinguish the two kinds of cells, especially in a tangential section. In the genus Salix the same relation exists (Fig. 21, *a*), with the difference that interspersal is a much more common feature, and the distinction of the two kinds of cells may be made without any difficulty in any plane of section. The relations thus indicated show that there is a tendency toward replace-

ment of the more primitive cells (1) by those (2) of a more advanced and specialized functional value; and this tendency is carried to such an extent that in low rays the replacement is often complete (Fig. 15). It is of interest from a developmental point of view to note that this relation is precisely that which has already been shown to exist among the higher gymnosperms, with respect to the relative preponderance of parenchyma cells and ray tracheids, and such a comparison goes far to prove, especially in connection with other relations to be described immediately, that the cells of the second order are of the higher type of development.

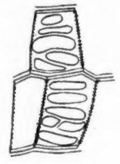

FIG. 22.—*Salix sessilifolia*. Radial section of a cell of the second order (2) showing complete transformation into scalariform structure opposite a vessel. × 350.

The features thus described for the radial section of the medullary ray, are of both generic and specific value as will be seen from the diagnoses given, but it should be pointed out that the recognition of two forms of cells in the medullary ray of the Salicaceæ is exactly parallel with what has already been noted as characteristic of the Coniferales (Penhallow, :04c), though with one important difference. In the gymnosperms the ray contains in its more primitive condition, parenchyma cells only, although these later become differentiated into two specialized forms. As a whole, these are equivalent, from the standpoint of development and functional value, to cells of the first order in the Salicaceæ. But in all the higher Coniferales the ray also contains specialized ray tracheids which manifestly provide greater freedom in radial circulation, and as already shown elsewhere, (Penhallow, :04c), such development is in direct response to the requirements of a higher type of organization. No such tracheids occur in the rays of the Salicaceæ, but they are exactly represented in a functional sense by the cells of the second order (2), which also serve as evidence of a higher type of organization.

While it is not our present intention to discuss the phylogeny of the Salicaceæ in detail, and to establish its relative position in the scale of evolution, it is desirable to indicate that the general trend of the evidence so far collected — geographical,

geological, anatomical—is all in one direction, and that is to show that the genus Populus is essentially the more primitive member of the family, and that it is the genus through which we must probably seek connection with ancestral forms.

It only remains to point out that with respect to a delimitation of species and varieties, the rule adopted for the gymnosperms (Penhallow, :04c) applies with equal force here, to the effect that varieties have no proper status on anatomical grounds, and what are designated as such on the basis of external morphology must be regarded as species from the standpoint of the present studies.

SALICACEÆ.

Transverse.— Growth rings usually devoid of recognizable differentiation of spring and summer wood, the outer limits being defined by a usually resinous wood parenchyma of radially narrower cells, forming a zone upwards of three elements thick. Wood cells variable, hexagonal, and usually not in obvious radial rows. Vessels numerous throughout, often predominant, and more or less radially compounded.

Radial.— Medullary rays composed of two kinds of cells, *i. e.*, those without (1) and those with (2) pits on the lateral walls opposite vessels. Vessels commonly with thyloses, their radial walls with numerous, multiseriate, usually localized, oval, round, or hexagonal bordered pits.

Tangential.— Medullary rays chiefly narrow ; 1- or more rarely 2-seriate in part. Vessels with numerous, multiseriate, hexagonal, bordered pits throughout.

1. **Populus.**

Radial.— Ray cells of two kinds but presenting no essential distinction as to length, height, and thickness of the walls ; the pits on the lateral walls of cells (2) more definitely rounded, oval or sparingly angled, when they become quadrangular and lie in radial series, never merging into scalariform structure.

Tangential.— The two kinds of ray cells not clearly distinguishable.

SYNOPSIS OF SPECIES.

Ray cells (2) (tangential) more or less distinguishable by differences in height, breadth, and less resinous contents.

Rays (tangential) 2-seriate in part.

Ray cells (1) somewhat variable, oblong, narrow, or broader and oval; unequal.

Vessels (transverse) broad, oval, 1- to 3-, more rarely 5-compounded. 1. *P. fremonti.*

Rays (tangential) strictly 1-seriate.

Ray cells (1) (tangential) uniform, narrow, oblong, equal, but occasional rays with broader, oval, and somewhat variable, unequal cells.

Vessels (transverse) broad, oval, or transversely oval, 1- to 2- or rarely 4-compounded. . . . . . . 3. *P. alba.*

Vessels (transverse) broadly oval, 1- to 4- or rarely 7-compounded. 4. *P. tremuloides.*

Ray cells (1) (tangential) uniform, narrowly oblong, and equal, but in different rays sometimes broadly oblong.

Vessels (transverse) very numerous, broad, 1- to 3- or rarely 4-compounded. . . . . 5. *P. pyramidalis.*

Vessels (transverse) numerous, much smaller toward the outer face of the growth ring, 1- to 4- or rarely 5-compounded. 6. *P. grandidentata.*

Ray cells (2) (tangential) not distinguishable from (1).

Rays (tangential) all strictly 1-seriate.

Rays (tangential) with diminishing terminal width.

Vessels (transverse) at first predominant, gradually diminishing in size and number, 1- to 3-, rarely 4- to 5-compounded. 7. *P. wislizeni.*

Rays (tangential) of uniform width throughout.

Vessels (transverse) numerous, oval, 1- to 4- or rarely 5-compounded. . . . . 8. *P. balsamifera.*

Vessels (transverse) at first predominant, gradually diminishing in size and number; 1- to 4-, rarely 6-compounded. 9. *P. angustifolia.*

Vessels (transverse) numerous throughout, abruptly smaller in the outer portions of the growth ring; 1- to 4-compounded. 10. *P. trichocarpa.*

Vessels (transverse) numerous, large, oval, or round, often in series continuous and compounded with those of the previous season; chiefly single but often 2-, and on the outer face of the growth ring sometimes 3-compounded. . . 11. *P. heterophylla.*

Rays (tangential) 2-seriate in part.

Rays (tangential) uniform in width throughout.

Vessels numerous throughout, broadly oval, abruptly fewer in the region of the summer wood, chiefly single, or less frequently 2- to 3-compounded. . . . . . 2. *P. monilifera.*

1. *P. fremonti* Wats.

Transverse.— Growth rings very broad, the limiting zone of wood parenchyma devoid of resin, 1 to 2 cells thick. Vessels large, broad, oval, becoming somewhat abruptly smaller toward the outer limits of the growth ring; 1- to 3-, more rarely 5-compounded. Rays numerous, sparingly resinous, one cell wide, distant upwards of 12 rows of wood cells.

Radial.— Ray cells (1), the upper and lower walls thin and finely pitted; the terminal walls straight or curved and finely pitted. Cells (2), the upper and lower and terminal walls thin, very finely and obscurely pitted; the pits on the lateral walls forming a coarse, sieve-plate structure.

Tangential.— Rays medium to high, numerous, 1-seriate, very sparingly resinous, sometimes 2-seriate. The cells (1) somewhat variable, oblong and narrow or broader and oval, unequal. Cells (2) not conspicuously different but the terminal ones sometimes higher, the interspersed ones sometimes narrow.

2. *P. monilifera* Ait.

Transverse.— Growth rings medium to narrow, the limiting wood parenchyma devoid of resin, in 2 to 3 rows. Vessels numerous throughout, broadly oval, becoming rather abruptly fewer at the outer limits of the ring, chiefly single, or less frequently 2- to 3-compounded. Medullary rays prominent, numerous, very sparingly resinous, and distant upwards of 6 rows of wood cells, one cell wide.

Radial.— Rays sparingly resinous, the cells contracted at the ends. Cells (1), the upper and lower walls rather thick, unequal, and finely pitted; the terminal walls thick, straight or curved, and finely pitted. Cells (2), the upper and lower walls thick and finely though remotely pitted; the terminal walls often strongly curved, thick, and finely pitted; the pits on the lateral walls round, oval, or sparingly angled, in radial series.

Tangential.— Medullary rays very numerous, low to high, very sparingly resinous, 1-seriate or sometimes 2-seriate in part. Cells (1), uniform in the same ray and oblong, equal but in different rays ranging from very narrowly oblong to rather broadly oblong. Cells (2) not distinguishable.

3. *P. alba* (Linn.).

Transverse. — Growth rings narrow, uniform, the limiting wood parenchyma very sparingly if at all resinous, in 1, sometimes 2 rows. Medullary rays prominent, somewhat resinous, 1 cell wide, distant upwards of 8 or sometimes 10 rows of cells. Vessels broad, oval, or transversely oval, at first predominant, gradually diminishing in size and number outwardly; 1- to 2-, or more rarely 4-compounded.

Radial. — Medullary rays very sparingly resinous. Cells (1), the upper and lower walls rather thick, finely but strongly pitted; the terminal walls straight, often diagonal, finely pitted; equal to about 6 wood cells. straight. Cells (2), the upper and lower walls somewhat thinner and not obviously pitted; the terminal walls conspicuously though finely pitted; the pits on the lateral walls hexagonal, forming a coarse, sieve-plate structure; somewhat variable in height and sometimes rather short.

Tangential. — Rays numerous, very sparingly resinous, medium, 1-seriate. Cells (1) chiefly uniform, narrow, oblong, and equal, but occasionally rays with broader, oval, and somewhat variable and unequal cells. Cells (2), uniform, narrow, somewhat variable, the terminal ones often much higher.

4. *P. tremuloides* Michx.

Transverse. — Growth rings broad, uniform; the limiting wood parenchyma sparingly resinous, in 1 to 2 rows. Vessels at first medium, becoming larger and finally smaller toward the outer limits of the growth ring, broadly oval, 1- to 4- or more rarely 7-compounded. Medullary rays rather numerous, one cell wide, sparingly resinous, distant upwards of 10 rows of wood cells.

Radial. — Ray cells sparingly resinous, straight. Cells (1), the upper and lower walls thin, and finely pitted; the terminal walls thin, straight or curved, and rarely pitted. Cells (2), the upper and lower walls thin and sparingly pitted; the terminal walls rarely pitted, often curved; the pits on the lateral walls round, chiefly in radial series.

Tangential. — Rays numerous, resinous, low to high, 1-seriate. The cells (1), uniform, narrowly oblong and equal, low rays sometimes showing broader and oval cells throughout. Cells (2) not readily distinguishable, but in low rays sometimes twice as high and less resinous.

5. *P. pyramidalis* Ait.

Transverse. — Growth rings rather broad, uniform; the limiting wood parenchyma in 1 to 2 rows, sparingly resinous. Vessels very numerous, broad, becoming gradually smaller toward the outer limits of the growth ring; 1- to 3-, more rarely 4-compounded. Medullary rays prominent, narrow, one cell wide, numerous, and distant upwards of 7, more rarely 10 rows of cells; somewhat resinous.

Radial. — Medullary rays sparingly resinous; the cells straight, becoming much shorter in the region of the summer wood. Cells (1), the upper and lower walls thin and strongly pitted throughout; the terminal walls finely pitted. Cells (2), the upper and lower walls thin and sparingly pitted; the terminal walls finely pitted; the pits on the lateral walls round or sparingly angled.

Tangential. — Rays very numerous, resinous, medium to high, narrow, 1-seriate. The cells (1) chiefly uniform, rather narrowly oblong and equal in the same ray, but in different rays sometimes varying to broadly oblong. Cells (2) not readily distinguishable except by their less resinous contents and somewhat more variable form and unequal size, usually giving the ray a diminishing terminal width.

6. *P. grandidentata* Michx.

Transverse. — Growth rings narrow, uniform; the limiting wood parenchyma with thin-walled cells in 1 to 3 rows, often very resinous. Vessels numerous throughout the growth ring but usually much smaller near the outer limits of the ring; 1- to 4-, more rarely 5-compounded. Medullary rays prominent but narrow, 1 cell wide and distant upwards of 10 or sometimes 12 rows of cells; somewhat resinous.

Radial. — Ray cells straight. Cells (1), the upper and lower walls thin and entire or obscurely pitted; the terminal walls thin, straight, or curved, finely pitted. Cells (2), the upper and lower walls rather thin and not obviously pitted; the terminal walls often strongly curved, rather thick, and conspicuously pitted; the pits on the lateral walls oval or round in radial series. Isodiametric, thin-walled idioblasts, containing each a single crystal of calcium oxalate of the quadratic system, often form extensive, longitudinal series adjacent to vessels.

Tangential. — Medullary rays numerous, narrow and high, strictly 1-seriate, resinous. The cells (1) chiefly uniform in the same ray and narrowly oblong, equal; but between different rays varying to oblong. Cells (2) not very readily distinguishable, but usually less resinous and often variable from narrowly oblong to oval so as to give the same ray a conspicuously unequal width.

7. *P. wislizeni* Watson.

Transverse. — Growth rings broad; the limiting wood parenchyma sparingly resinous in 1 to 3 rows. Vessels at first predominant, gradually diminishing in size and number toward the outer limits of the growth ring; 1- to 3-, more rarely 4- to 5-compounded. Medullary rays prominent, narrow, one cell wide, distant upwards of 10 rows of cells, numerous, sparingly resinous.

Radial. — Ray cells straight, equal to about 14 wood cells but becoming very short toward the outer limits of the growth ring. Cells (1), the upper and lower and terminal walls rather thin, rather obscurely and finely pitted; the pits on all the walls becoming much more prominent in the outer region of the growth ring. Cells (2), the upper, lower, and terminal walls not very different from (1); the pits on the lateral walls forming a coarse sieve-plate structure.

Tangential. — Rays numerous, narrow, medium to high, sparingly resinous, 1-seriate. Cells (1) uniform, narrowly oblong, and equal, sometimes becoming broader and oval in the central tract so as to form tapering extremities to the ray. Cells (2) not readily distinguishable but uniform, narrow, oblong, and equal.

8. *P. balsamifera* Linn.

Transverse. — Growth rings medium, uniform; the limiting wood parenchyma conspicuously resinous, of one or sometimes two rows of cells. Vessels numerous, oval, becoming gradually smaller toward the outer limits of the growth ring; 1- to 4- or more rarely 5-compounded. Medullary rays numerous, prominent, resinous, one cell wide, and distant upwards of 8 rows of cells.

Radial. — Rays strongly resinous, the cells straight. Cells (1), the upper and lower walls thin and finely pitted; the terminal walls straight or curved, obscurely if at all pitted. Cells (2), the upper, lower, and terminal walls thin and obscurely if at all pitted; the pits on the lateral walls round, in radial series.

Tangential. — Rays very numerous, strongly resinous, low to high, 1-seriate. Cells (1) uniform in the same ray and oblong, but varying between different rays from narrowly oblong to broadly oblong, equal. Cells (2) not distinguishable except by their less resinous contents.

9. *P. angustifolia* James.

Transverse.— Growth rings broad; the limiting wood parenchyma conspicuously resinous, usually upwards of 3 rows of cells thick. Vessels at first somewhat predominant, gradually diminishing in number and finally in size toward the outer limits of the growth ring where they are very much reduced in size; 1- to 4-, rarely 6-compounded. Medullary rays numerous, prominent, resinous, 1 cell wide, distant upwards of 9 rows of cells.

Radial.— Ray cells straight. Cells (1), the upper and lower walls unequally rather thick and strongly pitted; the terminal walls rather thick and strongly pitted. Cells (2), the upper and lower walls sparingly pitted; the terminal walls thin and sparingly if at all pitted; the pits on the lateral walls round or oval and radially seriate.

Tangential.— Medullary rays numerous and very variable, low to high, narrow, resinous, 1-seriate. Cells (1) uniform in the same ray and chiefly very narrowly oblong, equal, but in some rays becoming twice as broad and oblong. Cells (2) not distinguishable.

10. *P. trichocarpa* Torr. & Gr.

Transverse.— Growth rings very broad; the limiting wood parenchyma sparingly resinous. Vessels numerous throughout, becoming abruptly

smaller in the outer limits of the growth ring; 1- to 4-compounded. Medullary rays narrow but rather prominent and somewhat resinous; one cell wide, numerous and distant upwards of 12 rows of cells.

Radial.— Ray cells straight. Cells (1), the upper and lower walls thin and not obviously pitted except in the outer limits of the growth ring; the terminal walls straight or curved, and finely pitted. Cells (2), the upper and lower walls usually thick and more or less strongly pitted; the terminal walls rather thick and strongly pitted; the lateral walls with round or sparingly angled and radially seriate pits.

Tangential.— Rays rather numerous, resinous, high, narrow, strictly 1-seriate. Cells (1) chiefly uniform, narrowly oblong and equal, in a few rays becoming broader and oblong, somewhat unequal. Cells (2) not readily distinguishable.

11. *P. heterophylla* Linn.

Transverse.— Growth rings medium, rather uniform; the limiting wood parenchyma not very prominent, usually one cell thick and often forming a discontinuous zone. Vessels numerous and large, oval or round, often in series continuous and compounded with those of the previous year, diminishing steadily in size toward the outer face of the growth ring; chiefly single but often 2-, or on the outer face of the growth ring sometimes 3-compounded. Medullary rays not very prominent, 1 cell wide, rather numerous and distant upwards of 6 or more rarely 10 rows of cells.

Radial.— Medullary rays non-resinous. Cells (1), the upper and lower walls, as also the terminal walls, usually rather thick and strongly pitted. Cells (2), the upper and lower walls somewhat thinner, less strongly pitted; the terminal walls strongly pitted; the lateral walls with round, oval, or sparingly angled pits.

Tangential.— Medullary rays numerous, rather high, non-resinous, narrow, 1 cell wide. Cells (1) chiefly uniform in the same ray, oblong and equal, but between different rays varying from narrowly oblong to rather broadly oblong. Cells (2) not distinguishable from the first.

2. Salix.

Radial.— Ray cells (1) usually low and thick-walled, several times longer than high; the upper and lower and terminal walls commonly pitted. Cells (2) often thin-walled, marginal, and interspersed, commonly predominant, very variable, short, and often several times higher than long; the pits on the lateral walls more definitely angled, forming more extensive and finer sieve-plates, and sometimes merging into definite scalariform structure.

Tangential.— Ray cells clearly distinguishable as of two kinds.

Synopsis of Species.

Pits on the lateral walls of the ray cells (2) angled or oval and merging into an open, scalariform structure.

Resinous wood parenchyma prominent throughout in association with the vessels.

Rays (tangential) narrow, the cells (1) uniform, narrow and oblong.

Vessels oval, 1- to 2- or more rarely 3-compounded. 13. *S. sessilifolia.*

Resinous wood parenchyma confined to the outer limits of the growth ring.

Rays (tangential) numerous, resinous, and chiefly narrow. Cells (1) somewhat variable, chiefly oblong and narrow, more rarely oval, more or less conspicuously unequal.

Vessels broad (transverse), oval, 1- to 4- or finally 4- to 5-compounded. . . . . . . 14. *S. amygdaloides.*

Rays (tangential) resinous, numerous, broader; cells (1) variable, oblong to broadly oval and conspicuously unequal.

Vessels (transverse) predominant throughout, oval, 2- to 4- or finally 5-compounded. . . . . . . 15. *S. discolor.*

Rays (tangential) broad, more or less 2-seriate; the cells (1) variable, oval to oblong and conspicuously unequal.

Vessels (transverse) chiefly single throughout, but sparingly 2- to 3-compounded. . . . . . . 12. *S. lasiolepis.*

Pits on the lateral walls of the ray cells (2) hexagonal or quadrangular, forming coarse sieve-plates, but devoid of scalariform structure.

Resinous wood parenchyma conspicuous throughout the growth ring.

Resinous wood parenchyma confined to the vessels and the limiting zone.

Rays (tangential) numerous, resinous, 2-seriate in part; the cells (1) variable, narrowly to broadly oval, or round, or even squarish, very unequal. . . . . . 10. *S. longifolia.*

Resinous wood parenchyma numerous and often forming definite tracts.

Rays (tangential) very numerous, narrow; cells (1) uniform, oval, and chiefly equal throughout. . . . . . 11. *S. cordata.*

Resinous wood parenchyma confined to the limiting zone.

Rays (tangential) narrow, 1-seriate.

Ray cells (1) variable, oblong, narrow or more often broadly oval or squarish, unequal.

Vessels (transverse) at first broadly oval; 1- to 3- or finally 8-compounded and narrow. . . . . . 4. *S. nigra.*

Ray cells (1) uniform in the same ray but variable between different rays, narrowly oblong to oblong, chiefly equal.

Vessels (transverse) strongly predominant throughout, 2- to 3- or more rarely 4-compounded. . . . 5. *S. alba.*

Ray cells (1) somewhat variable, chiefly oblong or sometimes broadly oval; chiefly equal.

Vessels (transverse) strongly predominant, 2- to 5-compounded. 6. *S. lasiandra.*

Ray cells (1) chiefly uniform and oblong, sometimes oval; unequal, often twice as broad or twice as high.

Vessels (transverse) large, strongly predominant, 2- to 3- or rarely 4-compounded. . . . . . . 7. *S. lancifolia.*

Ray cells (1) uniform, oblong, chiefly equal.

Vessels (transverse) predominant, at first large, chiefly simple but 2- or very sparingly 3-compounded. 8. *S. brachystachys.*

Ray cells (1) narrow, chiefly uniform, oval or more generally oblong, equal.

Vessels (transverse) uniform in size and number throughout, except at the outer limits of the growth ring where they abruptly diminish in size; chiefly 1- often 2- to 3-compounded. . . . . 9. *S. scouleriana.*

Rays (tangential) broader, more or less 2-seriate.

Ray cells (1) uniform in the same ray, variable between different rays, oval or squarish, broad, unequal.

Vessels (transverse) predominant, 2- to 3- or more rarely 5-compounded. . . . . 1. *S. lævigata.*

Ray cells (1) uniform, oval, narrow, chiefly equal.

Vessels (transverse) single or somewhat 2- to 3-compounded. 2. *S. hookeriana.*

Ray cells (1) thin-walled, uniform, oblong, narrowly oval, equal.

Vessels (transverse) not predominant, 1- to 4-compounded, conspicuously fewer toward the outer limits of the growth ring. 3. *S. uva-ursi.*

1. *S. lævigata* Bebb.

Transverse.—Growth rings very broad; the limiting wood parenchyma about 3 cells thick, sparingly resinous. Vessels predominant throughout, at first rather large, radially oblong and very gradually reduced in size to the outer limits of the growth ring where they are about $\frac{1}{4}$ the original dimensions; 2- to 3- more rarely 5-radially compounded. Medullary rays numerous, resinous, prominent, 1 cell wide, distant upwards of 6 rows of cells.

Radial.— Rays resinous. Cells (1), the upper and lower walls thin and not pitted; the terminal walls finely pitted. Cells (2) sometimes predominant; the upper and lower walls thin and not pitted; the terminal walls finely pitted; the pits on the lateral walls forming a coarse sieve-plate structure.

Tangential.— Rays very numerous, medium to rather broad, 2-seriate in part, resinous. Cells (1) uniform in the same ray but variable in different rays, oval or squarish, unequal. Cells (2) uniform and narrowly oblong, strongly unequal, often several times higher than broad.

2. *S. hookeriana* Burr.

Transverse.— Growth rings very broad; the limiting wood parenchyma composed of rather distant and resinous cells. Vessels rather numerous, single or somewhat 2- to 3-compounded, oval, very gradually diminishing in size to the outer limits of the growth ring where they are $\frac{1}{4}$ to $\frac{1}{3}$ the diameter of the first. Medullary rays numerous, slightly resinous, 1 cell wide, distant upwards of 8 rows of cells.

Radial.— Rays rather sparingly resinous. Cells (1) more resinous; the upper and lower walls thick and very unequally, often sparingly pitted; the terminal walls rather strongly though finely pitted. Cells (2) less resinous, the upper and lower walls rather thin and devoid of pits; the terminal walls strongly and finely pitted; the pits on the lateral walls minute, simple and often slit-like when opposite wood cells, but forming a coarse sieve-plate structure opposite vessels.

Tangential.— Rays numerous, resinous, sometimes 2-seriate in part, low to high, narrow. Cells (1) rather uniform and oval, chiefly equal. Cells (2) variable, narrowly oblong and more or less conspicuously unequal, rather thin-walled.

3. *S. uva-ursi* Pursh.

Transverse. — Growth rings narrow, variable, eccentric; the limiting wood parenchyma rather resinous and prominent; the wood cells thin-walled and squarish throughout with no obvious distinction of spring and summer wood. Vessels not predominant, 1- to 4-compounded and conspicuously few toward the outer face of the growth ring. Medullary rays 1 cell wide, very sparingly resinous, not prominent, distant upwards of 6 rows of wood cells.

Radial. — Medullary rays sparingly resinous. Cells (1), the upper and lower walls usually thin and not obviously pitted; the terminal walls somewhat strongly pitted. Cells (2), the upper and lower walls thin and not obviously pitted; the terminal walls finely pitted; the pits on the lateral walls forming a strong sieve-plate structure; strongly predominant.

Tangential. — Medullary rays low to medium, very narrow, sparingly resinous, 2-seriate in part, the cells chiefly thin-walled throughout. Cells (1) uniform, oblong, to narrowly oval; equal. Cells (2) uniform, narrowly oblong, unequal, and often several times higher than broad; usually predominant and often excluding (1).

4. *S. nigra* Marsh.

Transverse.— Growth rings broad, the inner region of the growth ring usually more dense; the limiting wood parenchyma sparingly resinous, in 1 to 2 rows of cells. Vessels numerous, large, rather broad, and oval, gradually diminishing in size and number toward the outer region of the growth ring and finally becoming few, narrow, and rather small; 1- to 3-compounded or in the outer portions of the ring often 8-compounded and narrow. Rays rather numerous, not very prominent, very sparingly resinous, 1 cell wide, and distant upwards of 8 rows of wood cells.

Radial.— Medullary rays locally resinous. Cells (1), the upper and lower walls rather thin and usually not obviously pitted; the terminal walls chiefly thin and devoid of pits. Cells (2), the upper and lower walls thin and devoid of pits; the terminal walls strongly but finely pitted; the pits on the lateral walls forming a strong sieve-plate structure.

Tangential.— Rays very numerous, medium, sparingly resinous, 1-seriate, and broad. Cells (1), variable, unequal, oblong and narrow or more often broad and oval or squarish; unequal. Cells (2) less resinous, variable but chiefly narrowly oblong, unequal, and differing in both height and width.

5. *S. alba* Linn.

Transverse.— Growth rings very broad, the limiting wood parenchyma 1 to 2 cells thick, resinous. Vessels strongly predominant throughout; large, oval, often oblong, chiefly single but often 2- to 3- or more rarely 4-compounded; not diminishing sensibly toward the outer face of the growth ring. Medullary rays numerous, somewhat resinous, 1 cell wide, distant upwards of 8 rows of wood cells.

Radial.— Rays sparingly resinous. Cells (1), the upper and lower walls thick, and strongly pitted throughout, the terminal walls generally curved and strongly pitted. Cells (2), the upper and lower and terminal walls strongly pitted; the pits on the lateral walls forming a strong sieve-plate structure; often approximating in height and general character to cells (1).

Tangential.— Rays resinous, numerous, narrow, medium. Cells (1) uniform in the same ray but variable in different rays, and ranging from narrowly oblong to oblong; chiefly equal. Cells (2) less resinous, uniform but unequal, differing greatly in height.

6. *S. lasiandra* Benth.

Transverse.— Growth rings broad; the limiting zone of wood parenchyma continuous, conspicuous and resinous, 1 to 2 cells thick. Vessels strongly predominant, radially and somewhat tangentially 2- to 5-compounded, steadily diminishing in size to the outer limits of the growth ring

where they are reduced to ½ or ⅓ the first size. Rays somewhat resinous, prominent, 1 cell wide, distant upwards of 6 rows of wood cells.

Radial.— Rays somewhat resinous. Cells (1), the upper and lower walls rather thick and often strongly pitted; the terminal walls thick and strongly though finely pitted. Cells (2) more resinous, often predominant; the upper and lower walls thin and not pitted; the terminal walls thicker and strongly though finely pitted, the pits on the lateral walls forming a prominent sieve-plate structure.

Tangential. — Rays numerous, resinous, narrow, chiefly medium. Cells (1) somewhat variable, chiefly oblong or again broadly oval; chiefly equal. Cells (2) uniform and narrowly oblong; very unequal and often several times higher than broad.

7. *S. lancifolia* Anderss.

Transverse.— Growth rings broad; the limiting wood parenchyma resinous and prominent. Vessels rather large and strongly predominant throughout, radially oval and 2- to 3- rarely 4-compounded; diminishing very gradually in size to the outer limits of the growth ring where they are about two thirds the first diameter. Medullary rays numerous, resinous, and prominent, 1 cell wide, distant upwards of 6 rows of cells.

Radial.— Rays resinous. Cells (1), the upper and lower walls thick and unequally though often strongly pitted; the terminal walls thick and strongly though finely pitted. Cells (2), the upper and lower and terminal walls thick and strongly pitted; the pits on the lateral walls forming a coarse sieve-plate structure.

Tangential.— Rays numerous, resinous, narrow, medium. Cells (1) chiefly uniform and oblong, but varying somewhat from oval to oblong; unequal and often twice as broad or twice as high. Cells (2) much less resinous, uniform, narrowly oblong, unequal.

8. *S. brachystachys* Benth.

Transverse.— Growth rings broad; the limiting zone of wood parenchyma not resinous. The wood cells large, rather thin-walled throughout. Vessels predominant throughout; at first large, radially oval, chiefly single but 2- or very sparingly 3-compounded; gradually diminishing in size to the outer limits of the growth ring where they become 2- to 5-compounded. Medullary rays numerous, non-resinous, 1 cell wide, distant upwards of 10 rows of cells.

Radial.— Rays non-resinous. Cells (1), the upper and lower walls rather thin and not obviously pitted; the terminal walls with very fine pits. Cells (2), the upper and lower walls thin and not pitted; the terminal walls some-

what thicker and very finely pitted; the pits on the lateral walls forming a coarse, sieve-plate structure.

Tangential.— Rays numerous, narrow, low to rather high, somewhat resinous. Cells (1) uniform, oblong, chiefly equal. Cells (2) uniform, narrowly oblong, very unequal, and often several times higher than broad.

9. *S. scouleriana* Bebb.

Transverse.— Growth rings medium; the limiting zone of wood parenchyma somewhat resinous, 1 to 3 cells thick. Vessels somewhat uniform in size and number throughout, except at the outer limits of the growth ring where they abruptly diminish in size; oval, rather broad, chiefly 1-, but frequently 2- to 3- more rarely 4-compounded. Medullary rays numerous, prominent, resinous, 1 cell wide, and distant upwards of 8 rows of cells.

Radial.— Medullary rays resinous. Cells (1), the upper and lower and terminal walls thick and strongly pitted throughout. Cells (2), the upper and lower and terminal walls rather thick and strongly pitted; the pits on the lateral walls forming a prominent sieve-plate structure.

Tangential.— Rays numerous, resinous, medium, narrow, 1-seriate. Cells (1) narrow, chiefly uniform, oval or more generally oblong, equal. Cells (2) uniform, narrowly oblong but very unequal, and often several times higher.

10. *S. longifolia* Muhl.

Transverse.— Growth rings usually very broad but very variable and sometimes very narrow. Wood parenchyma cells numerous, very resinous, and associated with the vessels as well as forming an open zone on the outer face of the growth ring. Vessels predominant throughout, especially in the earlier portions of the growth ring; at first rather large, oval, and 1- to 3-compounded, later somewhat reduced, round, and simple or somewhat 2-compounded. Medullary rays numerous, resinous, 1 to 2 cells wide, distant upwards of 6, or more rarely 10 rows of wood cells.

Radial.— Medullary rays resinous. Cells (1), the upper and lower walls sparingly pitted, the terminal walls strongly but finely pitted. Cells (2), the upper and lower walls rather thick but not obviously pitted, the terminal walls very strongly pitted; the pits on the lateral walls forming a coarse sieve-plate structure.

Tangential.— Rays very numerous, resinous, 2-seriate in part. Cells (1) very variable, from narrowly to broadly oval, or round, or even squarish, very unequal. Cells (2) uniform, narrowly oblong but unequal and generally with thinner walls.

11. *S. cordata* Muhl.

Transverse.— Growth rings broad, terminated by 2 to 3 rows of radially flattened, rectangular wood cells; the limiting wood parenchyma prominent,

resinous; the structure rather dense throughout. Vessels not predominant; at first very numerous and very resinous, quickly diminishing in number and thence constantly diminishing in size and number, and always distant, to the outer face of the growth ring; rather small, oval, sparingly 2- or more rarely upwards of 4-compounded; everywhere numerous. Resinous wood parenchyma cells numerous throughout; associated with vessels and scattering throughout the growth ring, often forming more or less definite and extensive tracts. Medullary rays very numerous, resinous, 1 cell wide, distant upwards of 10 rows of cells.

Radial.— Ray cells very resinous. Cells (1), the terminal walls very thick and very strongly pitted; the upper and lower walls sparingly if at all pitted except in the later portions of the growth ring. Cells (2), often predominant; the upper and lower walls thin and not pitted except in the later portions of the growth ring; the terminal walls strongly pitted; the pits on the lateral walls forming a coarse sieve-plate structure.

Tangential.— Rays very numerous, medium, narrow, resinous. Cells (1) uniform, oval, and chiefly equal throughout. Cells (2) variable, oblong, often very narrow and unequal, often several times higher than broad, the walls commonly thinner.

12. *S. lasiolepis* Torr.

Transverse.— Growth rings broad; the limiting wood parenchyma 1 to 4 cells thick, sparingly resinous. Vessels at first not strongly predominant; oval or oblong, steadily diminishing in size and finally much reduced; chiefly single throughout, but sparingly 2- to 3-compounded. Medullary rays numerous, locally resinous, 1 to 2 cells wide, distant upwards of 6 rows of wood cells.

Radial.— Medullary rays resinous. Cells (1), the upper and lower walls sparingly and unequally pitted, often devoid of pits; the terminal walls strongly but finely pitted. Cells (2), the upper and lower walls chiefly rather thin and devoid of pits; the terminal walls strongly pitted; the pits on the lateral walls forming a coarse sieve-plate structure often coalescing into a coarse scalariform structure.

Tangential.— Rays very numerous, medium, resinous, 1- to 2-seriate. Cells (1) variable, oval to oblong, and conspicuously unequal. Cells (2) less resinous, variable, and unequal, often high.

13. *S. sessilifolia* Nutt.

Transverse.— Growth rings broad; the limiting wood parenchyma 1 to 2 rows of cells broad, occasionally resinous and confluent with resinous wood parenchyma in the adjacent spring wood. Vessels numerous and predominant throughout; radially oval and variable in size; 1- to 2-, more

rarely 3-compounded, especially at the outer limits of the growth ring where they are diminished to ¼ size. Resinous wood parenchyma more or less prominent throughout the growth ring in association with the vessels. Medullary rays numerous, rather prominent and resinous, 1 cell wide, distant upwards of 10 rows of wood cells.

Radial.— Rays somewhat resinous. Cells (1), the upper and lower and terminal walls strongly though rather finely pitted throughout, more resinous than the next. Cells (2) less resinous, often predominant; the upper and lower walls rather thin and sparingly pitted; the terminal walls strongly though finely pitted; the pits on the lateral walls variable, hexagonal, and forming a coarse, sieve-plate structure which more commonly becomes an open scalariform structure through transitional forms.

Tangential.— Rays sparingly resinous, low to medium, numerous, narrow. Cells (1) chiefly uniform, narrow, oblong, equal. Cells (2) uniform, narrowly oblong, very unequal and often several times higher than broad, less resinous than (1).

14. *S. amygdaloides* Anderss.

Transverse.— Growth rings broad; the limiting zone of wood parenchyma 1 to 4 cells thick and not obviously resinous. Vessels broad, oval, at first predominant, soon diminishing slightly in size and number toward the outer face of the growth ring where they are again somewhat abruptly reduced in size; at first oval, rather broad, and 1- to 4-compounded; finally much reduced in size and width and becoming 4- to 5-compounded. Medullary rays numerous, 1 cell wide, not resinous, and distant upwards of 16 rows of wood cells.

Radial.— Medullary rays more or less resinous. Cells (1), the upper, lower, and terminal walls rather thin and finely, the first obscurely if at all pitted. Cells (2), the upper and lower and terminal walls rather thin, the last finely but conspicuously pitted; the pits on the lateral walls forming a coarse sieve-plate structure often coalescing to form an open scalariform structure.

Tangential.— Rays very numerous, resinous, medium, chiefly narrow, 1-seriate. Cells (1) somewhat variable, oval or chiefly oblong and narrow, more or less conspicuously unequal. Cells (2) chiefly uniform, unequal, often several times higher.

15. *S. discolor* Muhl.

Transverse.— Growth rings broad, the limiting zone of wood parenchyma chiefly resinous. Vessels predominant throughout, radially oval, and 2- to 4-, more rarely 5-compounded especially at the outer limits of the growth ring, where they are diminished to ½ size. Medullary rays resinous,

prominent and numerous, 1 cell wide; distant upwards of 6 rows of wood cells.

Radial.— Rays resinous. Cells (1), the upper and lower and terminal walls thick, strongly but finely pitted. Cells (2), the upper and lower and terminal walls thick, finely but strongly pitted; marginal and interspersed, often predominant; the pits on the lateral walls variable and hexagonal, and forming a coarse sieve-plate structure which often passes through transitional forms into a scalariform structure.

Tangential.— Medullary rays resinous, numerous, low to high. Cells (1) variable, oblong to broadly oval, and conspicuously unequal. Cells (2) chiefly uniform and narrow, but very unequal and often several times higher than long, terminal, and interspersed, often predominant.

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ERRATA.

Page 515, line 29, for "Proteaceæ which is preëminently," read Proteaceæ which thus appears to be. Line 30, for "19 : 0.00," read *1 : 0.41*.

Page 516, line 9, for "forty-seven" read *fifty*-seven.

Page 516, first line of table, Proteaceæ, for "19:0.00" read *1:0.41*; for "19" read *24*; for "0.00" read *10* and insert "the whole" in the nineteenth line after Araliaceæ.

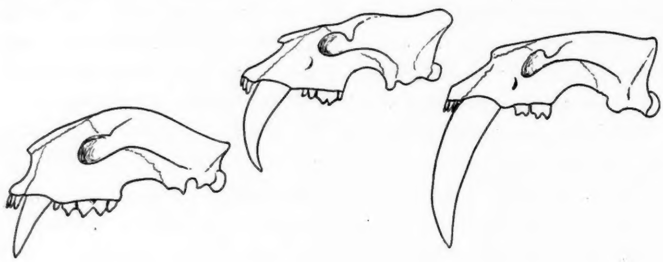
MOMENTUM IN VARIATION.

F. B. LOOMIS.

EVER since the theory of evolution was grounded and the fact that each form and species is the result of accumulated variations from a less specialized ancestor, was established, this same variation has been scrutinized to find its causes and laws. Darwin made it more or less sporadic, and saw in the struggle for existence the factor which selected the useful variations and eliminated the less suitable innovations. Later, recognizing many features, especially ornamental characters, as not useful, he also proposed sexual selection as a second factor in determining the preservation of variations. Others, especially paleontologists, have been struck by the fact that variations are in a line, so that useful features develop rapidly; and second, by the frequency with which several lines of variation appear in a form practically simultaneously, all in conformity to the particular habitat and habit of the possessor. Further, remarkable convergences are found in animals of different groups when placed in the same habitat. These facts lead to two lines of thought: first, that the environment acts on the animal more than merely to select such variations as chance may offer; and second, that the animal in its life, by its habits, acquires characters which are handed to its offspring accentuated, and thus adaptive features are rapidly developed.

In the above an explanation is found for the development of useful characters, but there remain still two classes to be accounted for. First, those which in their early stages are of no account, but when developed become important (as the cusps on teeth); and second those which have developed to perform a useful function but in later forms have reached a degree of specialization which has proved either a hindrance or the destruction of the possessor. To this class also belong those features developed to a degree of perfection beyond the requirements of utility (sponge spicules, Radiolarian shells, some plant blossoms).

For instance in the early members of the family of saber-toothed tigers (Machærodidæ), the upper canine teeth are elongated and flattened, making in such forms as Dinictis and Hoplophoneus a most efficient weapon. However, the elongating went on gradually until in a form like Smilodon the great tushes reach far below the lower jaw, and to open the mouth wide enough to take in food below the weapons was practically impossible, so that most of the food probably went in between the



a *b* *c*

FIG. 1. — Series of saber-toothed tigers' crania. *a*, Dinictis; *b*, Hoplophoneus; *c*, Smilodon.

canines. At this stage the family, world wide in its distribution, died out.

Taking this as an illustration of a variation going beyond its utility, there seems to the writer to be but one adequate explanation, namely, that as a special feature develops it attains a momentum which tends to carry it beyond the point of greatest utility. In so doing it may become a hindrance even to the point of exterminating its possessor, or may merely attain a perfection, not detrimental, but without other explanation.

Let this be applied to various groups. In the Radiolarian shell enough symmetry to maintain the balance of the animal would be expected, but when a mathematical perfection is shown in the repetition of every spine and ray in marvelous complexity, something more than utility has been subserved. The same may be said of the flesh spicules of sponges. At first being merely a deposition of something spinous in the flesh, so as to be disagreeable enough to protect the sponge from being eaten by small animals, these spicules are later carried to the perfection of

symmetry. These, with the symmetry of sessile crinoids, sea anemones, and floating jelly-fishes offer illustrations of the carrying of a feature far beyond utility, toward perfect symmetry.

The molluscan Hippurites starts as a form which thickens its shells, one of them especially, apparently as a protective measure. But when the shell has reached a thickness of an inch it can hardly be considered useful to increase it further. However, these forms go on increasing in thickness to in some cases over a foot, using up the vitality which would otherwise be available for reproduction. Momentum seems to be the only reasonable explanation in such cases, and there are several (Coralliopsidæ, Gryphea, Caprinidæ, etc.).

Among Cephalopoda the complication of the edge of the septum of various Ammonites offers another case. A sinuous mar-

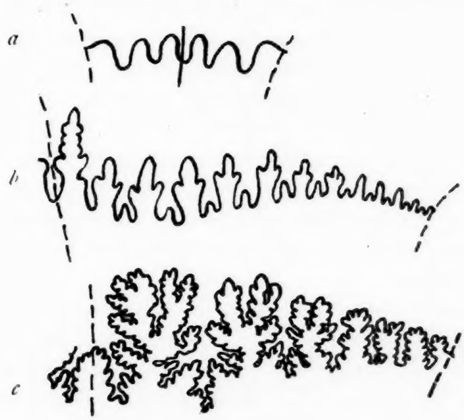


Fig. 2. — Series showing suture lines of Ammonites. *a*, Goniatites; *b*, Medliocottia; *c*, Desmoceras.

gin is doubtless a better brace against the pressure of the outside sea water, and such an irregular line as that of Goniatites or even Medliocottia (see Fig. 2) would be interpreted as useful. However, when it is carried to the complication found in Desmoceras or Pinacoceras, only momentum seems to explain the condition.

Turning to the vertebrates where the balance required for survival is even more delicate, the tooth of the Labyrinthodonts

is another instance. Here the surface is at first infolded probably for greater strength, but this is carried to a degree so complex as to be a puzzle to work out. Among the reptiles the Stegosaurian family adopted a dermal armor which some members developed till the double dorsal row of plates set on edge consisted of pieces some of which are over three feet across and several inches thick at the base. With such an excessive load of bony weight entailing a drain on vitality, it is little wonder that the family was short-lived. Doubtless the elongation of the snout was useful to the forms ancestral to Teleosaurus, but carried to the excess found in that genus, it resulted in a weak grasp, and the form disappeared.

Among the mammals the saber-toothed tigers have been mentioned. The mammoth with its extreme development of tusks may also serve to illustrate the principle. For, while at first the moderate tusk is an efficient weapon, as soon as it begins to be recurved as in *Elephas primigenius*, it loses its defensive value, and the carrying of the great weight is a drain on the vitality. A better example is seen in Babirusa where the canine teeth at first developed to protrude outward and of utility in digging, have gradually curved up over the snout, and appear more like horns than teeth. As they are now and were for a considerable portion of their previous development, they must be a serious hindrance in feeding.

The horns of many forms have also developed beyond usefulness. Take for instance those of the elk and moose, where if useful it is only in conflicts with other males once a year. But their great spread is a constant menace, requiring care lest in running they come to trees not far enough apart to admit of going between. Then the drain on the animal which sheds these great bony growths annually and replaces them again, is great. It is only as the result of momentum that these cases seem reasonable.

Among sheep where excessively heavy horns, such as those of the Kamchatka sheep and the big-horn, are developed, the great weight which lends force in butting can hardly be considered to offset the disadvantage which they entail in climbing and running. Wherever horns have been developed there seems to

be this tendency to carry them to excess, as in Titanotheres, Tinoceras, Elasmotheres, Irish elk, etc.

The above are selected examples in which a feature once useful has been developed beyond its maximum utility. Many others equally striking might be cited, the explanation of all of which is extremely difficult unless such a factor as momentum is called in. In the light of this factor, however, a logical and apparent cause is found. Momentum also explains why a character that originated in accordance with the environment develops so rapidly, and why, when an animal had reached adjustment to its surroundings, it still goes on beyond a perfect adjustment. It may be laid down as a rule then that *a variation started along any line tends to carry that line of development to its ultimate, being driven by momentum.* If the feature is detrimental the group dies out ; if, however, it is merely a minor feature it makes a handicap. A line of development may be stopped and its momentum overcome but the tendency is to keep right on.

This factor of momentum has not been given the importance due it, although it is felt in the undercurrent of the thought of several authors. It is the writer's belief, however, that it should find an important place in the explanation of animal structures.

AMHERST, MASS.

NOTES AND LITERATURE.

ZOÖLOGY.

A New Comparative Histology.[1]—The enormous mass of observations accumulated by histologists during the last decade has been greatly in need of such a treatment as would reduce its essentials to a compact and serviceable form. Schneider's *Lehrbuch der vergleichenden Histologie*, though a most excellent book in many respects, can scarcely be said to attack the problem from this standpoint, for its treatment of the subject on the basis of the descriptive histology of a series of representative animals has given to it so strongly an individual bent that it is a voluminous contribution from the author to comparative histology rather than a *résumé* of our present knowledge of that field. The *Traité d'Histologie* by Prenant, Bouin, and Maillard[1] on the other hand is a most successful attempt at this almost Herculean task. The work is planned for two volumes, of which the first, complete in itself, has just been published and the second is promised before the close of this year.

The first volume, whose subtitle is General and Special Cytology, is divided into three parts. The first of these includes Book I, dealing with protoplasm and the cell in general; Book II, giving the general morphology of the cell; Book III, taking up cellular physiology; and Book IV, indicating the lines of cellular differentiation. The second part, which contains Books V to VIII, has to do with the various forms of differentiated cells: sensory, muscular, nutritive, and sustentative. The third part includes Book IX on cell multiplication, X on individual reproduction, and XI on cellular degeneration and death. Each of these subjects has received an exhaustive and thorough treatment and not only are the facts concerning a given form of tissue well recorded but the present stand of the appropriate theoretic questions is unusually well stated. From the standpoint of a comparative histology which seeks to give the reader the main facts of the science and to orient him so far as the chief theoretic questions are concerned, the volume is without an equal and should prove a great boon to all histologists.

[1] Prenant, A., Bouin, P., et Maillard, L. *Traité d' Histologie. Tome I, Cytologie générale et spéciale.* Paris, C. Reinwald, 1904. xxxii + 799 pp., 791 figs.

In one respect the volume falls short of what it might have been. Little or no attention is given to the phylogeny of tissues and while this aspect of the subject is necessarily chiefly theoretic, a broadly grounded treatment cannot afford to omit it. Aside from this the volume is most acceptable. The presswork is excellent and the numerous figures, many of which are in color, afford a most ample body of illustrations for the text. There is a very full table of contents and an excellent index.

G. H. P.

Studies in Heterogenesis.[1]—One hundred years ago, Oken believed he had evidence that animal and vegetable tissues disintegrate after death to give rise by rearrangement of their elementary parts to minute living things which combine in larger and larger aggregates to form the myriads of infusion-dwelling microscopical organisms. Such an hypothesis is excusable with Oken in 1805, but in 1905, after more than sixty years of cell study, — after complete establishment of the dictum *omnis cellula e cellula*, the limit of toleration is overreached and we read with ever growing impatience the mass of so called evidence that dead protoplasmic substance is directly metamorphosed into living organisms of diverse species, genera, and even kingdoms.

This "evidence" is beautifully presented in 350 pages of letter press, with an appendix of 35 pages, and with 815 illustrations from microphotographs, by which, as the author tells us, the careful student can "help to break down the barrier of incredulity which at present excludes any general acceptance of the truth and universality of those processes of heterogenesis by means of which, as I believe, the lower forms of life, both animal and vegetal, are ever springing up anew in countless myriads from matrices wholly unlike themselves" (page 3). The photographs are fairly well taken and illustrate many common forms in stagnant waters but to present them as proof of heterogenesis recalls the *naiveté* of the small boy offering his pole and line as evidence of the ten-pound bass that escaped his hook.

Without going too much into details here, we may sum up the author's point of view by the following results which he believes are proved by his "evidence": —

1. Aggregates of bacteria in the zoöglœa stage may be transformed into fungus germs, or into Amœbæ, Mastigophora, or even into ciliated Infusoria (pp. 65–108).

[1] Bastian, H. C. *Studies in Heterogenesis.* London, Williams and Norgate, 1903. 8vo, ix + 354 + xxxvii pp., 19 pls. 31/6.

2. Ciliated Protozoa may be formed indifferently from such zoöglœa masses, or from the substance of Amœbæ (pp. 113–118), or from encysted Euglena (pp. 110–113), or from the eggs of Macrobiotus (pp. 138–144) and rotifers (pp. 44–45).

3. Diatoms, even, may arise *de novo* from the cells of a parasitic alga (pp. 158–168); or Actinophrys from the substance of Nitella cells, or from Euglena (p. 224). The latter, indeed, seems to be something of a protoplasmic Pandora's box from which emerge Peranema (p. 13), Polyphagus (p. 224), Olpidium (p. 226), Chytridium (p. 232), Chlamydomonas (p. 234), Amœba (p. 235), or higher algæ like Vaucheria (p. 188) and Conferva (p. 191), while its own protoplasm may be only the metamorphosed substance of an algal cell (Œdogonium).

As to the method employed in obtaining these remarkable findings there is little said; isolation and continuous observation were deemed unnecessary and fruitless. Tap water with hay for example, was heated to not more than 125° F. and left to stand. A scum developed after a few days, in which, from day to day, various types of organisms, including monads, fungus germs, Actinophrys, and even ciliates were observed, all having developed, he concluded, from "embryonal areas" of the scum. These observations are seriously presented as proving the heterogenetic origin of the different forms. Answering a criticism from certain "learned societies" that had refused to accept his conclusions based upon this method of observation, Bastian states: "I submit that such evidence as has been brought forward in this volume is the only kind of evidence that can be adduced in proof of heterogenesis" (p. 344), and this statement, if limited to his use of the term heterogenesis, is one and the only one in which we heartily and unqualifiedly agree with the author.

G. N. C.

Herrick's Home Life of Wild Birds.[1]—In the four years since the appearance of Professor Herrick's earlier work under this title, he has been able to extend his studies of nesting habits to a larger number of species and individuals, and in the present revised edition of his book "much has been re-written, and forty-eight new illustrations have been added to the text in place of a smaller number omitted. The first three chapters have been materially changed;

[1] Herrick, Francis H. *The Home Life of Wild Birds. A New Method of the Study and Photography of Birds.* New York and London, G. P. Putnam's Sons, 1905. 8vo, xxv + 225 pp., illus. $2.00.

Chapter XI. on Nest-Building is entirely new, as are also in large measure those which follow on The Development and Care of the Young and on Life and Instinct." The size of the volume has been reduced so as to make it serviceable for field use.

For the serious and minute study of the life of birds at their nests, the author's "method" has its great advantages as well as its limitations. A small tent, described fully in Chapter III, "Tent and Camera," is erected within arm's length of the nest to be studied and the observer is enabled to watch the activities of the birds through a small window cut at the proper height in the tent-wall. The camera is also used from the shelter of the tent. In cases where the nest cannot be conveniently reached from the ground it is removed together with the nesting-limb and set up in a favorable spot, where it may be readily observed from the tent. The instinct of the parent birds to care for their young is so strong that they soon return to their charges and, finding that no harm comes from the tent, they quickly learn to disregard it entirely. It is important to note, however, that such liberties may not be taken with a nest until the young are hatched and are a few days old, for if disturbed earlier than this the old birds will desert. For this reason the very early life of the nestling cannot be so well studied by this method. Professor Herrick has used his "method," with good judgment and in but "four or five cases when the nest with its supports has been displaced . . . . have the young come to grief, in the course of five years' work."

The first three chapters of the volume are given to an exposition of the "method," then follow chapters on the nesting habits of the robin, the cedar-bird, the red-eyed vireo, the bluebird, the catbird, the nighthawk, and the belted kingfisher, with photographic reproductions of the various activities that take place at the nest. The remaining chapters are of a more general nature and treat briefly of nest-building, the development and care of the young, life and instinct, and the instinct of fear in young birds. From his studies of a number of species, the author has come to regard a large part of the activities of nesting as instinctive. "Birds seem to follow one line of conduct, whether it be building nests, sitting over eggs, or brooding and tending the young, until their instinct in any given direction has been satisfied, thus normally completing one term of the series before passing to the next in sequence . . . . Each term of the cycle is capable of analysis into many minor components, differing not only in the sexes, but in different species, and subject to change in different individuals . . . . One instinct may be overdone, as when a bird like

the phœbe builds more than one nest, in which case her building instinct is apparently not satisfied by the usual exercise, or another may be scamped, as when swallows, house martins, or swifts desert their young in order to start on their migrations. When one instinct has been satisfied, wild birds must obey the next in sequence, which seems to possess them with the force of a resistless passion."

Apart from its interest as literature, the book from a purely scientific point of view, contains much of value with regard to the habits of certain of the species treated. Thus the nighthawk is found to feed its young, in one case at least, upon fireflies; the cleaning of the nest and removal of excreta is a duty regularly performed by the small birds studied; the parents do not attempt to feed each young bird in turn impartially, but often thrust food into a nestling's throat and withdraw it to try a second or a third young one until a bird with the "proper reaction time," *i. e.*, whose swallowing reflex is stimulated, is found. Brooding, or shielding the young from the heat, is part of the parents' duty on hot days, and it would be of interest to determine if this act is confined to birds that build open nests. Domed nests might be expected to dispense with the necessity for shielding the young from the sun's heat and possibly this may explain their origin.

The book itself is well printed and profusely illustrated. The style is popular but the author has used much judgment in his treatment of a field which "in the direction of both observation and experiment is of boundless extent, while on the side of inference it is full of pitfalls." The remarkable photographs by which the book is illustrated, add largely to its interest and value.

G. M. A.

Trouessart's Catalogus Mammalium, Supplement, Fasc. 4.[1] — The concluding part of this work, the first three fascicles of which have already been noticed in these columns (*Amer. Nat.*, vol. 39, pp. 603–605), lists the known living and fossil Cetacea, Edentata, Marsupialia, Allotheria, and Monotremata, and brings the total of known mammalian species up to 9381, an increase of 2157 over the number listed in the *Catalogus* of 1897–99. Among the Cetacea the great need for revisionary work is apparent and many of the species will doubtless be found to be merely nominal when more material can be

[1]Trouessart, E. L. *Catalogus Mammalium tam Viventium quam Fossilium. Quinquennale Supplementum (1899—1904).* Fasc. 4. Berlin, R. Friedländer & Sohn, 1905. 8vo, pp. i–vii, 753–929. 8 Marks.

gathered and studied. Forster's name, *ampullatus*, revived by Rhoads (*Science*, N. S., vol. 15, p. 756, 1902) appears to have escaped the compiler, and seems applicable in place of *rostratus* for Hyperoödon. Four new generic names are proposed, to take the place of others that are preoccupied. Sphenodontherium for Sphenodon, Heterodontherium for Heterodon, and Propareutatus for Pareutatus among the Edentata, and Odontocyrtus for Kurtodon among the Marsupialia. The compiler also deems it necessary to amend the name Tatu to Tatus. The index includes those specific names only that have figured in works published since the previous catalogue.

G. M. A.

BOTANY.

Britton's Manual.[1] — In form, the recently issued second edition of this now well known work conforms closely to the first edition published in 1901. Analytical keys to the families, prepared by Wiegand, have been added to the prefatory matter, and a key to the genera of Compositæ, also prepared by him, has been placed at the end of the treatment of that family. The lamentable absence of necessary synonymy from the first edition has been rectified tc a considerable extent; and in addition to such corrections as were possible in the original text, the appendix has been amplified by the incorporation of descriptions of over 100 species not recognized in the earlier edition, while, *e. g.*, under Cratægus, the fact that still others have been published is indicated.

W. T.

A New North American Flora.[2]—Since the appearance some years ago of the latest fascicle of the *Synoptical Flora* begun by Asa Gray, there has been no evident effort to provide a collective systematic treatment of the plants of the entire United States, though several handbooks covering a part of the country have appeared.

The fascicle now under review, though pertaining to a volume far

[1]Britton, N. L. *Manual of the Flora of the Northern States and Canada.* New York, Henry Holt and Co., 1905. 8vo, 2 ed., revised and enlarged, xxiv + 1112 pp.

[2]*North America Flora*, vol. 22, part 1.—Published by the New York Botanical Garden, May 22, 1905. Large 8vo, 80 pp. $1.50.

advanced in the series is in reality the initial number of a new work which is intended to describe the wild plants of all groups not only of the United States but of the remainder of North America, including the West Indies. The editorial management has been undertaken by Doctors Britton and Underwood, who have associated with themselves an advisory committee of representative American botanists, and who depend upon the collaboration of a large number of specialists. Thirty volumes of four or five fascicles each are in contemplation, and a special fund set aside for this purpose by the New York Botanical Garden provides for the publication of the several parts as they are prepared.

The present fascicle, which is attractively printed and provided with analytical keys for all of the groups treated, is devoted to the first four (Podostemonaceæ, Crassulaceæ, Penthoraceæ, and Parnassiaceæ) of the twenty-four families recognized as representing the order Rosales; the first being handled by Nash, the second by Britton and Rose, and the third and fourth by Rydberg, the ordinal key and description being by Small.

So large an undertaking is subject to many dangers and is certain to suffer many mishaps; and, considering the imperfect herbarium data and the impossibility of extensive field research if the work is to be pushed forward with any speed, it may be said that each fascicle is likely to become antiquated in a very short time after its publication, so far, at least, as the tropical regions are concerned, — the more rapidly, indeed, in proportion to its own critical excellence. There appears to be no other way, however, of making possible the ultimately complete flora of this enormous and botanically rich territory that every botanist feels the need of, and the editors should count on the active support of all who can help them forward with their plans.

W. T.

Ames's Studies in the Family Orchidaceæ.[1] — A new irregular-interval publication, somewhat comparable with *Hooker's Icones Plantarum*, the *Icones Selectæ Horti Thenensis*, etc., has been launched under the auspices of a publisher's house which does only good and attractive work. Its purpose is to present the results of investigation on one of the largest and best known collections of

[1] Ames, Oakes. *Orchidaceæ. Illustrations and Studies of the Family Orchidaceæ, issuing from the Ames Botanical Laboratory, North Easton, Massachusetts.* Boston and New York, Houghton, Mifflin and Co., 1905. 8vo, fasc. 1, vi + 156 pp., 16 pls.

orchids cultivated in the United States, its scope being limited to this family of plants. The first fascicle, issued on April 8, contains illustrations, critical notes, and technical descriptions covering a wide range of genera in the family and a number of countries. The most interesting feature for American botanists is a critical paper called "Contributions toward a Monograph of the American Species of Spiranthes," to which 33 pages are devoted.

W. T.

Notes.— The fourth of Rose's "Studies of Mexican and Central American Plants" (*Contributions from the U. S. National Herbarium*, vol. 8, part 4), like its predecessors is an important addition to the published information about the plants of the high tableland. The author states that none of the many new species it contains have been described until all their known Mexican relatives had been studied, and in most cases a synopsis of the genus prepared,— a procedure that speaks well for the conclusions reached.

A paper on plants eaten by the ancient Mexicans, by Urbina, has been published from the Museo Nacional of Mexico.

Nuttall's *Journal of Travels into the Arkansas Territory during the Year 1819, with Occasional Observations on the Manners of the Aborigines*, published at Philadelphia in 1821, is reprinted as vol. 13 of the *Early Western Travels* being edited by Dr. Thwaites of the Wisconsin Historical Society.

Under the title "Plant Migration Studies," Professor Bessey has distributed from *University Studies*, vol. 5, no. 1 (University of Nebraska) separates of an analysis of the distribution of Nebraska trees and the factors which have influenced it,— with 67 thumb-nail maps of the State, referring to as many trees.

The forest conditions of northern New Hampshire are considered by Chittenden in *Bulletin no. 55* of the Bureau of Forestry, U. S. Department of Agriculture.

A paper entitled "Additions to the Flora of Subtropical Florida," by Small, has recently been issued in the *Bulletin of the New York Botanical Garden.*

A contribution to the flora of the Bahama Islands, by Britton, is separately printed from vol. 3, no. 11, of the *Bulletin of the New York Botanical Garden.*

A monograph of Portuguese Orobanchaceæ, by Guimaraes, is published in *Broteria* for 1904.

Among other forest views, the *Report of the Forestry Bureau of the Philippine Islands* for the year ending September 1, 1903, recently issued, contains a good photogram showing the aërating roots of *Bruguiera caryophyllæoides*.

Mutation is discussed from various points of view in a series of papers printed in *Science* of April 7.

The megaspore membrane of Gymnosperms forms the subject of a paper by Thomson, published as no. 4 of the biological series of *University of Toronto Studies*.

Haywood publishes a paper on the injury to vegetation by smelter fumes, as *Bulletin no. 89* of the Bureau of Chemistry, U. S. Department of Agriculture.

The great scope of economic botanical study by the Government Bureau of Plant Industry, which spends annually nearly a million dollars, is well shown by the recently issued *Report of the Secretary of Agriculture for the Year ending June 30, 1904*.

The prickly pear and other cacti as food for stock are discussed by Griffiths in *Bulletin no. 74* of the Bureau of Plant Industry, U. S. Department of Agriculture.

A paper by Mann and Hunter on sisal-hemp culture in the Indian tea districts has been published recently by the Indian Tea Association of Calcutta.

An illustrated article on commercial Catalpa growing, by Gleason, is contained in *Country Life in America* for May.

Vol. 9 of the *Contributions from the U. S. National Herbarium* consists of an account of the useful plants of the island of Guam, by Safford.

Some large trees are noted and figured by Tavares in vol. 3 of *Broteria*.

The remarks of a number of biologists, chemists, and engineers on the use of copper sulphate for the purification of water supplies are published in *Science* of April 21.

The decays of timber due to higher fungi are reached in Lieferung 6 of Lafar's *Handbuch der Technischen Mykologie*, pertaining to volume 3.

The fungous diseases of orchard trees are considered by Wilcox in *Bulletin no. 132* of the Alabama Agricultural Experiment Station.

Three (edible) species of Coprinus are figured by Arthur in *Bulletin no. 98* of the Purdue University Experiment Station.

Sclerotinia padi and the diseases it causes are described by Lambert in an illustrated article in *Gartenflora* of April 1.

Nomenclatorial type specimens of plant species are discussed by Hitchcock in *Science* of May 26. In connection with some of the suggestions of this article should be read another, on general grounds, by Schuchert, in the same journal of June.

A noteworthy monograph of the genus Nymphæa, in quarto (xiii + 279 pp., 30 pls.), by Conard, has recently appeared as *Publication no. 4 of the Carnegie Institution of Washington.*

The development of *Sarracenia purpurea* is discussed by Shreve in *The Johns Hopkins University Circular*, no. 178.

Maiden's revision of the genus Eucalyptus has reached the 6th part, ending with p. 180 and pl. 32.

An anatomical study of *Croomia paucifolia* is published by Holm in *The American Journal of Science* for July.

A revision of the genus Zexmenia, by Jones, forms n. s., no. 30, of the "Contributions from the Gray Herbarium of Harvard University," published as vol. 41, no. 7, of the *Proceedings of the American Academy of Arts and Sciences*, issued June 23.

Stages in the development of *Sium cicutæfolium* are described by Shull in *Publication no. 30 of the Carnegie Institution of Washington.*

Recent publications on South American cacti are: Arechavaleta, "Flora Uruguaya," 2 entrega, forming part of the *Anales del Museo Nacional de Montevideo*; and Spegazzini, "Cactacearum Platensium Tentamen," in ser. 3, vol. 4, of the *Anales del Museo Nacional de Buenos Aires*, which Mr. Berger is summarizing in recent issues of the *Monatsschrift für Kakteenkunde.*

A paper on the haustoria of Santalum, by Barber, is published in *The Indian Forester* for April.

A paper on the development of *Phytolacca decandra*, by Lewis, is published in *The Johns Hopkins University Circular*, no. 178.

A preliminary paper by Johnson, on seed development in the Piperales and its bearing on the relationship of the order is published in no. 178 of *The Johns Hopkins University Circular.*

An account of the Jamaican species of Lepanthes, by Fawcett and Rendle, forms vol. 7, part 1, of the current botanical series of *Transactions of the Linnean Society of London.*

Teratological flowers of Agave are described by Maige in the *Revue Générale de Botanique* of April 15.

The North American species of Agrostis are revised by Hitchcock in *Bulletin no. 68* of the Bureau of Plant Industry, U. S. Department of Agriculture, under date of April 29.

A facsimile reprint of Cutler's "An Account of some of the Vegetable Productions naturally growing in this Part of America," from the first volume of *Memoirs of the American Academy of Arts and Sciences*, forms no. 7 (reproduction series no. 4) of the *Bulletin of the Lloyd Library*, issued in 1903.

An account of the vegetation of the "Sotol Country" in Texas, by Bray, forms *Bulletin no. 60* (scientific series no. 6) of the University of Texas.

An illustrated popular account of desert vegetation is given by Sharlot M. Hall in *Out West* for June.

Volume 9 of the "Flore de France" of Rouy, Foucaud, and Camus, published as the *Annales de 1904* of the Académie de la Rochelle, deals with Compositæ.

An account of new plants from the islands of Margarita and Coche, Venezuela, by Johnston, forming no. 29 of the new series of "Contributions from the Gray Herbarium of Harvard University," has recently been published as no. 21 of the current volume of *Proceedings of the American Academy of Arts and Sciences.*

A paper on the vegetation of Madeira, by Vahl, is contained in vol. 36, part 2, of Engler's *Botanische Jahrbücher.*

Vacciniaceæ and Ericaceæ (in part) are treated in the recently issued vol. 4, sect. 1, parts 1 and 2, of the "Flora Capensis" edited by Sir W. T. Thiselton-Dyer.

Papers on Indigofera (by Baker) and Aloë (by Schönland) are contained in vol. 1, part 4, of the *Records of the Albany Museum*, of Grahamstown.

The biological significance of leaf-fall is discussed by Wiesner in the *Berichte der deutschen botanischen Gesellschaft* of May 25.

A review of the identifications of the species described in Blanco's *Flora de Filipinas*, by Merrill, constitutes no. 27 of the publications of the *Bureau of Government Laboratories*, Manila, bearing date of April, 1905.

A paper by Pond on the biological relation of aquatic plants to the substratum has been separately issued, recently, from the *U. S. Fish Commission Report for 1903*.

Duggar's St. Louis address on present problems in plant physiology is printed in *Science* of June 23.

A translation, by Lloyd, of Gœbel's St. Louis address on the fundamental problems of present-day plant morphology is published in *Science* of July 14.

The mutations of Lycopersicum are discussed by White in *The Popular Science Monthly* for July.

A thesis on fruit and vegetable colors, by LaWall, is published in *The American Journal of Pharmacy* for July.

An important paper on the fly-galls of Juniperus is published by Howard in vol. 1, no. 2, of the ninth series of *Annales des Sciences Naturelles — Botanique.*

A paper on the morphology and anatomy of the stem of Lycopodium, by Jones, forms vol. 7, part 2, of the current botanical series of *Transactions of the Linnean Society of London.*

An extensive paper on the development of the ascus and spore formation in Ascomycetes (Contribution no. 61 from the Cryptogamic Laboratory of Harvard University) is published as vol. 32, no. 4, of the *Proceedings of the Boston Society of Natural History.*

The recently issued 17th volume of Saccardo's *Sylloge Fungorum* forms part 6 of the *Supplementum Universale* to the original work.

Postembryonal stages of the Laminariaceæ are described by Setchell in vol. 2, no. 4, of the *University of California Publications — Botany.*

A short paper on some Yellowstone diatoms is published by Edwards in *Nuova Notarisia* for July.

The cell structure of Cyanophyceæ forms the subject of a paper

by Fischer, published as no. 4–6 of the 63d volume of the *Botanische Zeitung, I Abtheilung.*

No. 8 (Mycological series no. 3) of the *Bulletin of the Lloyd Library*, dated April, 1905, contains an account by C. G. Lloyd of the Lycoperdaceæ of Australia, New Zealand, and neighboring islands.

An important paper connecting many Fungi Imperfecti with Ascomycetous forms has been published by Klebahn in vol. 41, heft 4, of the *Jahrbücher für wissenschaftliche Botanik.*

"Asparagus and Asparagus Rust in California" is the title of a well illustrated paper by Smith, published as *Bulletin no. 165* of the Agricultural Experiment Station of that State.

A paper on the grain-rust epidemic of 1904, by Carleton, forms *Farmers' Bulletin no. 219* of the U. S. Department of Agriculture.

Atkinson and Shore have published an illustrated paper on mushroom growing for amateurs as *Bulletin no. 227* of the Cornell University Agricultural Experiment Station.

A paper on apple scab and cedar rust, by Emerson, forms *Bulletin no. 88* of the Agricultural Experiment Station of Nebraska.

Orchard diseases are discussed by Wilcox in *Bulletin no. 132* of the Alabama Agricultural Experiment Station.

A popular summer key to our trees, by Julia Ellen Rogers, is published in *Country Life in America* for July.

Volume 3 of Marshall Ward's *Trees* deals with flowers and inflorescences, descriptively treated with reference to British forms.

Alwood, Davidson, and Moncure describe the composition of cider as determined by dominant fermentation with pure yeasts, in *Bulletin no. 150* of the Virginia Agricultural Experiment Station.

An agricultural-geographical study of rubber plants, with map, by Reintgen, forms no. 2–3 of the current volume of *Beihefte zum Tropenpflanzer.*

An account of native and introduced saltbushes, by Elias Nelson, forms *Bulletin no. 63* of the Wyoming Experiment Station.

The Mexican "guayule" (*Parthenium argentatum*) used as a source of caoutchouc, is the subject of an article by Endlich in *Der Tropenpflanzer* for May.

A well illustrated article by Fullerton, on "Roots We Eat," is contained in *Country Life in America* for July.

The wild legumes of Maryland are considered by Norton and Walls in *Bulletin No. 100* of the Maryland Agricultural Experiment Station.

A first paper on Wyoming forage plants and their chemical composition, by Knight, Hepner, and Nelson, forms *Bulletin no. 65* of the Wyoming Experiment Station.

A paper by Laurent on the "Flore pliocène des Cinérites du Pas-de-la-Mongudo et de Saint-Vincent-la-Sabie (Cantal)" forms vol. 9, part 1, of the *Annales du Musée d' Histoire Naturelle de Marseille.*

The Journals. — *Botanical Gazette,* April:— Thaxter, "A New American Species of Wynnea"; Shoemaker, "On the Development of *Hamamelis virginiana*"; Christman, "Sexual Reproduction in the Rusts"; Whitford, "The Forests of the Flathead Valley, Montana"; Livingston, "Note on the Physiology of Stigeoclonium"; Trow, "Fertilization in the Saprolegniales."

Botanical Gazette, May:— Dean, "On Proteolytic Enzymes — I"; Cardiff, "Development of Sporangium in Botrychium"; Livingston, "Physiological Properties of Bog Water"; Darbishire, "An Apparatus for observing the Transpiration Stream"; Lyon, "Polyembryony in Sphagnum"; Maxon, "Adenoderris, a Valid Genus of Ferns."

Botanical Gazette, June: — Arthur, "Leguminous Rusts from Mexico"; Cannon, "On the Water-conducting Systems of some Desert Plants"; Caldwell, "The Effects of Toxic Agents upon the Action of Bromelin"; Sargant, "The Early History of Angiosperms."

The Bryologist, May:— Fink, "Further Notes on Cladonias—V"; Arnell, "Phænological Observations on Mosses"; Towle, "Notes on the Fruiting Season of Catharinea"; Sargent, "Lichenology for Beginners"; Britton, "Notes on Nomenclature —V"; Cardot, "Notes on some North American Mosses — II"; Wood, "Additions to the Lichen Flora of Long Island"; Grout, "Notes on Vermont Bryophytes"; Holzinger, "Two Changes of Name."

The Bryologist, July: — Evans, "Diagnostic Characters in the Jungermanniaceæ"; Andrews, "Additions to the Bryophytic Flora of West Virginia"; Sargent, "Lichenology for Beginners — II"; Nicholson, "*Tortula pagorum*"; Britton, "A Long Lost Genus to the United States — Erpodium"; Fink, "What to note in the Macroscopic Study of Lichens."

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